VOLUME IV. NUMBER 5

THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

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PUBLISHED BI-MONTHLY

SEPTEMBER-OCTOBER, 1910

PRINTED FOR THE SOCIETY
TORONTO: 198 COLLEGE ST.
FOREIGN AGENTS: WILLIAM WESLEY & SON,
28 ESSEX ST., STRAND, LONDON.

THE JOURNAL

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ROYAL ASTRONOMICAL SOCIETY

OF CANADA

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Slit Widths and Errors of Measurement in Radial Velocity Determinations	*J. S. Plaskett*	333
Stellar Magnitudes	*J. E. Maybee*	345
Some Preliminary Results Deduced from Observed Radial Velocities of Stars	*W. W. Campbell*	353
The Mount Wilson Conference of the Solar Union	*C. A. Chant*	356
The Astronomical and Astrophysical Society of America	*J. S. Plaskett*	373
Johann Gottfried Galle	*C. A. Chant*	379
Meetings of the Society		
At Toronto	*L. G.*	386
At Ottawa	*C. E.*	388
At Hamilton	*T. H. W.*	390
At Regina, Saskatchewan	*H. S. McC.*	391
Notes from the Dominion Observatory		
Astrophysics	*J. S. P.*	394
Correction	*J. B. C.*	395
Magnetic Observations	*O. K.*	395
The Seismograph	*O. K.*	396
Notes from the Meteorological Service		
Report of the Weather in Canada, August-September	*R. F. S.*	400
Magnetic Observations		402
Earthquake Records at Toronto and at Victoria, B. C.	*J. Y.*	406
Book Reviews	*A., C. A. C.*	407
Astronomical Notes		
The New Astronomer Royal		409
The Astronomer Royal Who Retires	*J. R. C.*	409
Notes and Queries	*C. A. C.*	410
Predictions for November and December		416

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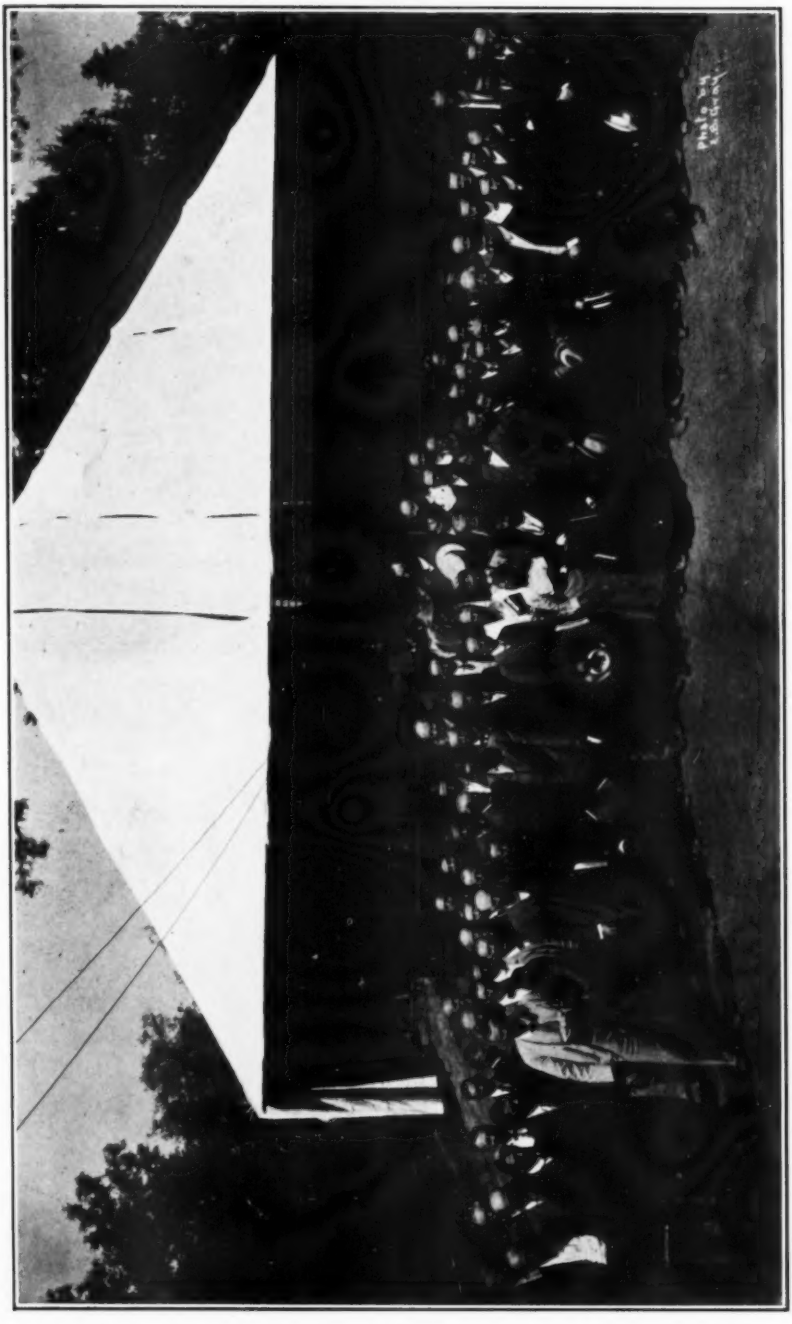
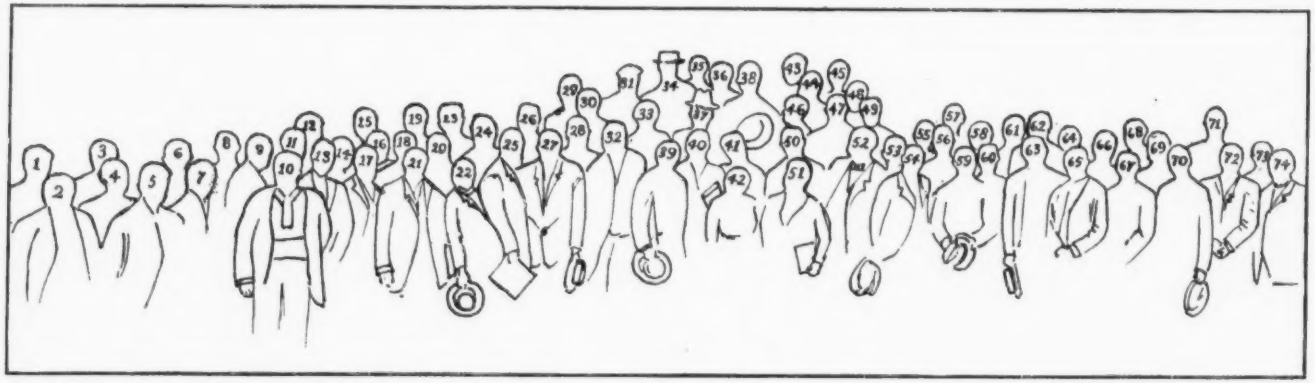
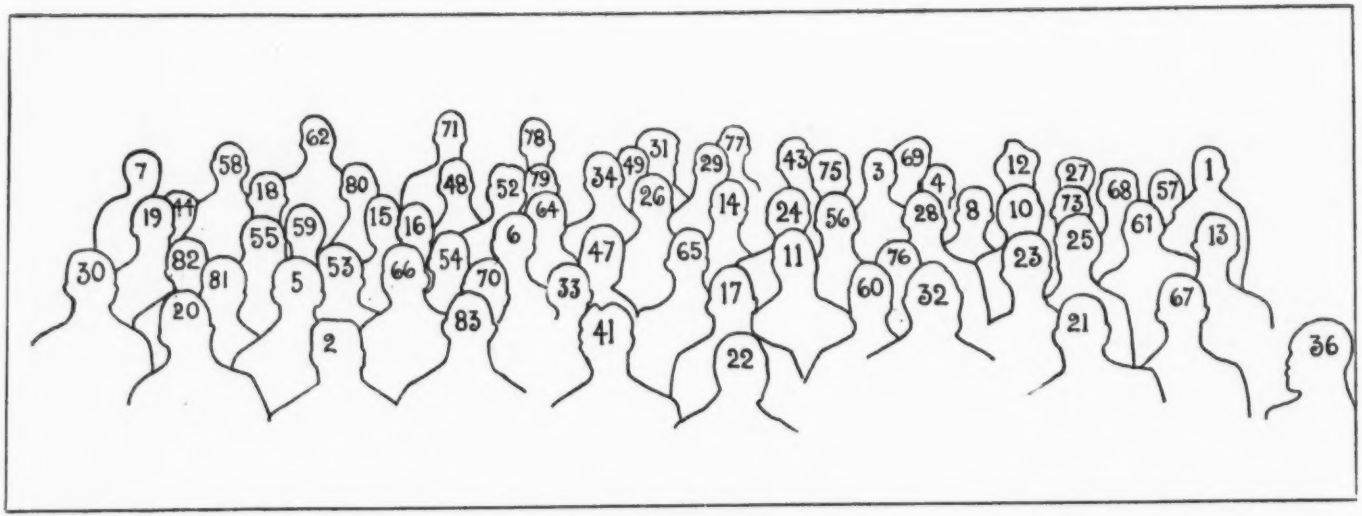


Members of the Fourth Conference of the International Union for Co-operation in Solar Research, Mt. Wilson, Cal., August 31 to September 2, 1910.



Key to Plate XX.

1 Ellerman
2 Wilson
3 St. John
4 Gilmore
5 Townley
6 Slipher
7 Coblentz
8 Fowle
9 Frost
10 Küstner
11 Hartmann
12 Puiseux
13 Slocum
14 Brackett
15 Hamy
16 Knight (Pasadena).
17 Wolfer
18 Rydberg
19 Fath
20 Haussmann
21 Hepperger
22 Cortie
23 Fox
24 Turner
25 Kayser
26 Russell
27 Adams
28 Backlund
29 E. Miller (Kansas)
30 Ames
31 Konen
32 Pickering
33 Fowler
34 Lampland
35 (Stenographer)
36 Belopolsky
37 Deslandres
38 Campbell
39 Hale
40 Schuster
41 Ricco
42 Mrs. Kapteyn
43 Bosler
44 Schwarzschild
45 Watson
46 McAdie
47 Schlesinger
48 Humphreys
49 Maddrill
50 Kapteyn
51 Mrs. Fleming
52 Sanford
53 Chretien
54 Fabry
55 Pluvinel
56 Hills
57 Abbot
58 Larmor
59 Cotton
60 Dyson
61 Barnard
62 King
63 Newall
64 Pringsheim
65 Leuschner
66 Plaskett
67 Chant
68 Gale
69 Eversheim
70 Rotch
71 Mitchell
72 Stratton
73 Babcock
74 Ritchey
75 Pease
76 Cirera
77 Richard (San Jose)
78 Seares
79 (Reporter)
80 Struve
81 Idrac
82 Lord
83 Donitch



KEY TO PLATE XXI.

(See other Key to Plate XX. for Names)

THE JOURNAL
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VOL. IV. SEPTEMBER-OCTOBER, 1910. No. 5

SLIT WIDTH AND ERRORS OF MEASUREMENT IN RADIAL VELOCITY DETERMINATIONS

BY J. S. PLASKETT

THE results of some experiments upon the effect of increasing the width of the slit upon the accuracy of radial velocity determinations by means of the spectroscope have been already published.* Since these investigations some further results have been obtained and it has seemed desirable to give these in this paper, incorporating therein a summary of the whole work.

It was shown in experiments† upon the dimensions of the star image, given by the system of visual objective and photographic correcting lens, which is focussed upon the slit of the spectrograph, that the actual effective diameter of this image is very much larger than that called for by the diffraction theory. Under this theory the angular diameter of the central disc in H_γ light for a 15-inch objective is 0·57 seconds, while photographic determinations of the diameter of star images and the widths of star spectra and star trails show a minimum diameter of about 2

* Report of Chief Astronomer 1906-7, p. 170 and 1907-8, p. 86, also *Astrophysical Journal* XXVIII., p. 259, Nov. 1908 and *Trans. Roy. Soc. Can.*, 1909, p. 209.

† Report of Chief Astronomer 1907-8, p. 79, also *Astrophysical Journal* XXVII., p. 148, March, 1908.

seconds. Newall's conception* of "tremor discs" serves to give an explanation of this enlargement in diameter as due to atmospheric tremor and considers the image to consist in effect of a central "core" surrounded by an outlying penumbra, whose respective diameters in the present instance are about 2 and 8 seconds. In my opinion this enlargement occurs in two ways, (1) The actual diameter of the diffraction disc is increased by atmospheric disturbance. (2) It is, from a similar cause, displaced in all directions from its true position.

There results then in photographic action, whether on the actual star images or their spectra, the integrated effect of such enlargement and displacement, giving generally a minimum diameter of about 2 seconds.

The standard slit width 0·025 mm. (·001 inch) is with the Ottawa telescope equivalent to about 0·9 second and it is evident that much of the star light will be intercepted by the slit jaws. Actual experiments for different slit widths† showed that the exposure time required for star spectra of equal intensity was very closely inversely proportional to the slit width until this reached about 0·13 mm. (·005 inches). The saving in time and corresponding increase in output rendered possible by the use of wider slits is, therefore, very marked and the purpose of the whole investigation is to determine what effect the widening of the slit will have upon the accuracy of the radial velocity measures.

Every spectroscopist engaged in radial velocity work must have noticed the very marked increase in breadth and diffuseness of the spectral lines, both absorption and emission, as the slit is widened, and must have felt convinced when the slit had reached a width of 0·051 mm. (·002 inch) that the extreme limit for accurate measurement had been attained. If the slit is made 0·076 mm. (·003 inch) wide the lines become so diffuse as to appear quite useless for velocity determinations, although, as will

* *M. N.* LXV., p. 608.

† Report of Chief Astronomer 1907-8, p. 81, also *Astrophysical Journal* XXVII., p. 150, March 1908.

appear later, this is not altogether the case. In view of the above considerations the experiments and measures throughout have been limited to four slit widths 0·025, 0·038, 0·051, 0·076 mm., 1, 1·5, 2, and 3 divisions on the usual graduation of the slit micrometer head.

As the relative accuracy of measurement of stellar spectra at different slit widths can not be determined theoretically, the only recourse is to make a number of spectra at each of the above slit widths, and measure and reduce the plates to obtain the probable errors.

Consequently plates for this purpose have been obtained at four different times with different spectrographs and conditions forming four series or parts of this investigations. The following is a brief summary of the conditions prevailing in each series. As indicated above, measures and results for the first two, and results for the third series have been published. For the sake of completeness the whole work will be summarized, paying of course, special attention to Series IV. which is entirely new.

INSTRUMENTAL AND OTHER CONDITIONS

Number of Series	Instrumental Constants					Number of Plates at each Slit Width	Star
	Spectrograph	Number of Prisms	Coll. Focus	Camera Focus	Tenth-Metres per mm. at Hγ		
			mm.	mm.			
I.	Brashear Universal	3	375	375	18·6	5	ζ Orionis
IIa.	Ottawa	1	525	525	30·2	6	ζ Orionis
IIb.	"	3	525	525	10·1	6	"
IIc.	"	3	525	275	18·2	6	"
IIIa.	New One Prism	1	765	455	33·4	10	ζ Orionis
IIIb.	Ottawa	3	525	300	17·5	6	"
IV.	New One Prism	1	765	455	33·4	10	α Bootis

The reason for dividing the work into parts has been chiefly due to changes in the instrumental equipment. After Series I. had been obtained with the Brashear Universal Spectroscope* the combined single and three prism instrument† was constructed

*This JOURNAL I., p. 104, March-April 1907.

†*Ibid* III., p. 287, July-August 1909.

and, as the previous results had been considered inconclusive, tests with the new instrument were conducted. In Series I., II*a*. and II*b*. the focal lengths of camera and collimator are equal and the minimum width of line will be the width of the slit. If the collimator is of longer focus than the camera, the width of the image of the slit will be diminished in the same proportion and the results previously obtained will not necessarily be valid. Hence Series II*c*., III*a*. and III*b*. In all the above cases the spectra were of the early type star β Orionis, in which only few lines and these only moderately sharp, were measured. In order to make the investigation complete, Series IV. with the solar type star α Bootis, which has a large number of sharply defined lines, was obtained.

In considering the errors of measurement introduced by widening the slit, a little consideration will show that they may be chiefly ascribed to three causes.

(*a*) To the loss of purity necessarily resulting from widening the slit, with the increasing difficulty of identification of the components of blends and determination of the effective wave lengths.

(*b*) To the increased breadth and diffuseness of the spectral lines with the probable effect upon the errors of pointing.

(*c*) To systematic displacements of the lines as a whole, with consequent error in the velocity, due to unsymmetrical position of the nucleus or "core" of the star image within the widened slit opening.

In order to simplify the question as much as possible, the star β Orionis was chosen as a test object for the first three series. Only single lines of moderate sharpness are present in Rigel and consequently no question of identification of wave lengths due to loss of purity can enter. Also in Series IV., although many complex blends of lines are present in α Bootis, no knowledge of their wave lengths is necessary when the plates are measured on the spectro-comparator. Hence case (*a*) may be omitted, and we need only consider the effects of (*b*) and (*c*) on the accuracy of the results.

It is evident that these two sources of error are in a sense entirely independent of one another. The former (*b*), that due to the increased width of the lines, evidently only affects the settings on the lines, is wholly accidental in character and may be relatively evaluated by obtaining the probable error of the velocity determination for a single line in the usual way. The latter (*c*), a systematic displacement of the star lines as a whole with respect to the comparison lines, will evidently not appear in and can not be determined from the measures of single plates. If due to errors of guiding, whereby the nucleus of the star image is not maintained centrally in the slit opening, the displacement on different plates will probably be of an accidental nature and may be evaluated by discussing the velocities of a sufficient number of plates at each slit width.

In determining (*b*) the accidental error, the procedure followed in the first three series has been as follows. After all the plates at any one slit width (varying from five to ten in the different series) had been measured and reduced,* the weighted mean velocity for each plate was determined and the residuals in kilometers per second for each line tabulated. It has seemed preferable, instead of obtaining the probable error of a line separately from each plate, to combine the residuals from all the plates at any one slit width and hence derive the probable error of an average line at this width. This is much simpler, and, owing to the small number of star lines measured, usually only three on each plate, more reliable than that obtained by discussing each plate separately.

The errors under (*c*), systematic errors, are obtained from the mean velocities of all the plates at each slit width, a relative measure of the magnitude being given by the probable error of a single plate obtained in the usual way. Such a method assumes necessarily either the constant velocity of the star observed or such a slow rate of change, that, during the interval over which the plates at any one slit width were obtained, such change of velocity is negligible. β Orionis was not at first

*Method given in Report of Chief Astronomer 1906-7, p. 95.

suspected of having a variable velocity, which was, indeed, only discovered from the measures obtained in Series II. However, the total range of velocity is so small, and the period 21·9 days so long compared with the interval occupied in making a set of plates at any one slit width, that no appreciable error can be introduced by using this star. It must not be forgotten that the plate velocities used in obtaining this probable error are each affected by an accidental error as well. The final values, therefore, do not represent the systematic errors only, but are composite in nature and give a measure rather of the total errors to be expected at the different slit widths, which is, in the final analysis, the most important factor to be determined.

The procedure outlined above has been followed in Series I., II. and III. for the accidental errors, case (*b*), and in all four series for the total errors, case (*c*), of measurement. In Series I. and II. from four to seven star lines were measured on each plate but the discussion of the measures showed that when the lines used in reduction were limited to three, λ4481·400, *Mg.*, λ4471·676 *He.*, and λ4340·634 *H.*, much better agreement was obtained. Consequently these lines only were measured in Series III. and the results in all three series are obtained from the velocities given by them.

In Series IV. for which neither the measures nor results have been published, and which necessarily must be discussed in rather more detail, the procedure has been somewhat different. The spectra here were of the solar-type star α Bootis and, in order to prevent difficulty due to loss of purity as the slit is widened, all the spectra were measured on the spectro-comparator. This instrument and its method of use have been fully described* and it is only necessary here briefly to refer to its main features.

The velocity of the star is obtained by the direct comparison of its spectrum with a standard or fundamental solar spectrum photographed by the same spectrograph. The velocity of the sun at any instant is known and when the displacement of the

**Astrophysical Journal* XXIV., p. 285; Report of Chief Astronomer 1908-9.

star lines relatively to the sun lines is known, the velocity of the star can be at once obtained. This relative displacement is determined on the spectro-comparator by superposing the two spectra, each with its accompanying comparison spectrum, by means of a double-objective single-ocular microscope. The images are placed beside one another, by a type of the Lummer-Brodhun cube in the ocular, so that a strip of star spectrum is seen between and touching two strips of sun spectrum with a similar effect for the comparison spectrum on each side. As the sun spectrum is placed on a carriage moveable longitudinally by an accurate micrometer screw, the relative displacement, in fractions of a revolution of the sun and star lines with respect to their comparison lines is easily and accurately measured. This linear displacement is converted into velocities by multiplication by a simply computed constant. It is evident from the method employed that the accuracy in no sense depends upon a knowledge of the exact wave lengths of the lines or blends compared, and that the loss of purity entailed by widening the slit will not be a factor in the results.

The relative displacements are measured at a number of regions distributed along the range of spectrum used, these regions being distinguished by ink dots on the standard solar spectrum. In the present series 9 regions between $\lambda 4100$ and $\lambda 4600$ were measured on each plate. The velocities for the regions were used, exactly as the velocities for the lines on a plate in determining the accidental errors, but in this case the probable error of a single region was determined for each plate separately, and the mean of these values for the plates at each slit width taken as a measure of the relative accidental errors. The total errors were obtained as before from the plate velocities at the various slit widths.

It is neither possible nor desirable to give here the separate measures of any of the series. They may be obtained with much other tabular matter in the Reports of the Chief Astronomer for the years 1906-7, 1907-8 and 1909-10. It will suffice simply to tabulate the final results in the different series, the probable

errors of single lines or regions and of single plates. In order to make the results at the different slit widths directly comparable with one another all the plates were obtained and all but Series II*c*., for whose measures I am indebted to Mr. Harper, were measured by myself. The final mean values depend upon 43 plates at slit width 0·038 mm. and 49 plates at each of the other three widths, making a total of 190 plates, a sufficiently large number to give dependable values. It may be as well to mention that the results for Series I. are slightly different from those already published owing to the fact that they depend upon three lines in each plate only. The new values render the final values more homogeneous.

PROBABLE ERRORS OF SINGLE AVERAGE LINES OR REGIONS

Series	Instrumental Constants				Plates at each Slit Width	Probable Errors at Slit Widths			
	No. of Prisms	Coll. Focus	Camera Focus	T. M. per mm.		0·025	0·038	0·051	0·076
I.	3	375	375	18·6	5	±2·75	±2·91	±4·11	±6.30
II*a*.	1	525	525	30·2	6	4·6	2·5	2·4	4·4
II*b*.	3	525	525	10·1	6	2·3	2·1	2·5	2·1
II*c*.	3	525	275	18·2	6	2·9	—	2·9	3·8
III*a*.	1	765	455	33·4	10	3·32	3·00	3·21	4·05
III*b*.	3	525	300	17·5	6	2·81	2·96	1·65	3·66
IV.	1	765	455	33·4	10	1·53	1·33	1·31	2·46

PROBABLE ERRORS OF SINGLE PLATES

Series	Instrumental Constants				Plates at each Slit Width	Probable Errors at Slit Widths			
	No. of Prisms	Coll. Focus	Camera Focus	T. M. per mm.		0·025	0·038	0·051	0·076
I.	3	375	375	18·6	5	±2·78	±0·63	±2·95	±4·18
II*a*.	1	525	525	30·2	6	1·7	2.7	3·0	7·7
II*b*.	3	525	525	10·1	6	1·5	1 3	0·7	0·9
II*c*.	3	525	275	18·2	6	2·1	—	3·0	2 9
III*a*.	1	765	455	33·4	10	3·14	1·86	1·47	3·32
III*b*.	3	525	300	17·5	6	0·84	1·88	1·87	2·43
IV.	1	765	455	33·4	10	0·61	0·54	0·71	3·23

If each of these series are weighted in conformity with the number of lines measured and plates used and according to their

relative dependability, the weighted means will give us a measure of the relative accuracy at the four slit widths employed. With the following weights.

Series I.	1	Series III*a*.	3
II*a*.	2	III*b*.	2
II*b*.	2	IV.	4
II*c*.	1		

We obtain

MEAN PROBABLE ERRORS AT SLIT WIDTHS

	0·025	0·038	0·051	0·076
Single Line	2·74	2·31	2·33	3·49
Single Plate	1·65	1·44	1·62	3·47

The errors of a single line give relative values of the accidental errors of measurement at the different slit widths, while the errors of a single plate give relative values for the total error. The former indicates the effect upon the measurements of the increasing breadth and diffuseness of the spectral lines, while the latter, although including this also, shows how far any possible asymmetric position of the nucleus of the star image within the widened slit opening affects the resultant velocities.

Let us consider first of all the purely accidental part of the effect of increased slit width. We notice in the detailed results that taken as a whole there appears to be no increase as the slit is widened from 0·025 to 0·051 mm. Indeed the mean values show a decrease from 2·74 to 2·33 km. per second. In the cases where the collimator is longer than the camera (II*c*., III*a*., III*b*., IV.) and where less increase in the width of lines would occur as the slit was widened than where collimator and camera are of the same focus, one would expect that such cases would give a more favorable showing in the probable errors. This is not distinctly shown although some evidences appear of such an effect; for example, compare Series I. with Series III. and IV. From the mean values of the probable errors we may evidently take it as

well established that so far as accuracy of measurement is concerned, there is certainly no advantage to be gained in using a slit narrower than 0·051 mm., but on the contrary this width in many cases gives a minimum value to the probable error. It is just as unmistakeably shown that a further increase to 0·076 mm. increases the probable errors by nearly 50 per cent, in practically the same ratio that the exposure time is decreased.

It is difficult to find an explanation for this curious and unexpected result, to tell why the broader lines given by a slit 0·051 mm. wide should give slightly more accurate results than the narrow and sharp lines resulting from a width of 0·025 mm. It may possibly be due to the well known fact that it is easier to make accordant pointings of a micrometer wire on a line somewhat broader than itself than on one so narrow and fine that it is covered or nearly covered by the wire. The fact remains that at least equal accuracy of measurement may be obtained by increasing the slit width so that only half the exposure time is required that was formerly thought necessary.

The purely accidental errors of measurement just considered are not, however, so important as the total errors of which relative values are given by the probable errors of single plates. A plate may give very good agreement among its various lines, resulting in a low probable error of measurement and yet give a resultant velocity differing greatly from the true one, owing to some instrumental cause that produces systematic displacements of the star lines as a whole with respect to the comparison lines. Such displacement will not appear in the measurement and can only be detected by comparison of a number of plates of the same star taken under such varying conditions as may render the effect accidental in character.

A measure of this accuracy at different slit widths is given in the tabulated "Probable Errors of Single Plates." A comparison of the results for the separate series as well as for the general mean shows a marked similarity in the relative values for the three narrower slit widths to those discussed above, and a similar increase although to a much greater degree, over 100

per cent in this case for the widest slit, 0·076 mm. employed. This shows that a widening of the slit from 0·025 to 0·051 mm. tends to slightly increase the accuracy of the velocity determinations but that a further widening to 0·076 mm. more than doubles the probable error and is not permissible in good work.

It is not so difficult in this case to find a satisfactory explanation of these results. The only effect that widening the slit can have in systematically displacing the lines must consist in its effect upon the uniformity of illumination of the collimator lens and in the position of the star image within the slit jaws. As previously stated the effective diameter of the nucleus or "core" of the image in the photographic light is about two seconds of arc, 0·055 mm. with the Ottawa telescope. As the slit is increased in width from 0·025 to 0·051 mm. there is a tendency towards more uniform illumination of the collimater lens, but when it is further widened to 0·076 mm. it is possible that the nucleus may be on the whole, during a short exposure, to one side or other of the centre. The first condition tends to increased accuracy, the last to diminished accuracy of the velocity determinations. As example of the last, an unsymmetrical position of the nucleus of 0·005 mm. results in a systematic shift of the lines with the single prism spectrograph of about 10 km. per second. A careful examination of the increase in the probable errors of single plates for slits 0·076 mm. wide will give us a confirmation of this hypothesis. It will be noticed that the increase is decidedly the greatest for the one prism instruments and only small with three prisms. This may be ascribed to two causes :—first, the smaller kilometer value for given linear displacement with three prisms ; and, second, the longer time of exposure required with the higher dispersion allowing the vagaries of seeing and guiding to give an integrated position of the image more nearly central than is likely in the very short exposures required with the one prism spectrograph.

The results here obtained may be briefly summarized as follows :

1. A previous investigation had shown that until the slit

became wider than 0·13 mm. the exposure time required is nearly inversely proportional to the slit width.

2. Actual tests of the relative errors at four different slit widths 0·025, ·038, ·051, ·076 mm. were made by exposing a number of spectra at each width with different dispersions and under varying conditions and then measuring these spectra.

3. The results of the measures of nearly 50 plates at each slit width showed that at least equal accuracy is attainable with a slit 0·051 mm. wide as with narrower slits, but that a further widening to 0·076 mm. results in an increase of 50 per cent. in the accidental and 100 per cent. in the total errors.

4. Combining 1 and 3 shows the possibility, by the use of wider slit than ordinarily employed, of a very considerable saving in exposure time and corresponding increase in output without loss of accuracy.

It gives me pleasure to express my appreciation of the interest shown by the Director, Dr. King, in the progress of this work.

DOMINION OBSERVATORY,
OTTAWA, CANADA.
July, 1910.

STELLAR MAGNITUDES

By J. E. Maybee

IT is an oddity of terminology and a survival of immemorial custom that a term expressive of size is used to designate the brilliancy of a star. Metaphorical language seems almost out of place in an exact science like Astronomy ; yet to the ordinary dabbler in Astronomy the term "magnitude," used to express light giving power, does not appear unapt, for we are well accustomed to speak of a man of brilliant intellectual or moral acquirements as a "big" man ; and, to the non-scientific, undoubtedly the biggest and most important point about a star is its relative brilliancy of appearance. So we shall accept the term "magnitude" as expressing the luminosity of a star as viewed from our earth.

The term is, as already suggested, an old one and comes to us from Ptolemy (140 A.D.). In the Ptolemaic cosmogomy, as is well known, the stars were supposed to be set in a crystalline sphere and were all at the same distance from the earth. It was not an unnatural assumption then that differences in brightness indicated difference in size. The final triumph of the Copernican theory of the universe resulted in the passing away forever of *this* theory of stellar magnitudes, but another quite as erroneous took its place, namely, the assumption that all stars are of the same intrinsic brilliancy and that the difference in their appearance is due simply to differences in their distances from us. We now know that some of the most brilliant of the stars are comparatively distant and that others relatively dim are among our nearest neighbors. We also know that there are dark stars, Algol's dark companion for example, and it is reasonable to assume, therefore, that stars vary not only in their distances from us but in their intrinsic lustre as well.

Stellar Photometry is the branch of astronomical science which undertakes the task of determining the relative apparent brightness of the stars and any variations therein.

It is an important branch of astronomical work, for when combined with determinations of parallax and spectroscopic analysis it enables us to get an approximate idea of the real sizes of stars. For it is evident that, given a star which differs from another in brightness, its distance and the *quality* of the light being the same, the difference of brightness gives at once a measure of the relative sizes of the two. Or, if the brightness and quality of light are the same but the distances different, the two stars vary in size directly as the square of the distance.

Working along such lines it is found for example that though 61 Cygni, mag. 5·4, distance 6·5 light years, is only one-seventh the solar mass, Arcturus, mag. 0·24, distance 127 to 160 light years, is possibly equal to a million suns.

Having arrived at an idea of the meaning of "magnitude" as applied to stars, and of the importance of stellarphotometry, we shall now consider on what lines stellar magnitudes are determined. Our present system of expressing magnitudes possesses several incongruities. In the first place, the smaller the magnitude the brighter the star. There would be no great trouble about this, however, were it not for the fact that some stars are brighter than first magnitude. Hence we have the anomaly of stars of 0 magnitude and even "–" magnitudes. Some further confusion is due to the fact that the eye does not perceive the actual ratio of brightness between two stars. For instance, a star of the 3·5 magnitude might be supposed to be a mean between a star of the sixth magnitude and a star of the first magnitude. But not so, a star of 3·5 magnitude is 12·6 times as bright as a star of the sixth magnitude. And a star of the first magnitude is 100 times as bright as a star of the sixth magnitude, and therefore 8 times brighter than a 3·5 magnitude star.

Following this out, it appears that if the brightness of a sixth magnitude star be called 1, that the brightness of a fifth magnitude star is 2·512, of a fourth magnitude star 6·3, of a

third 15·8, say 16, of a second magnitude star almost 40 and of the first just 100. Magnitude 0·0 is represented by 251·2 and magnitude −1 by 631. In each case the brightness relative to the sixth magnitude star is found by raising 2·512 to a power represented by the difference in the magnitudes. It follows then that to determine how many times one star is brighter than another you subtract the lesser magnitude from the greater and raise 2·512 (the light ratio) to a power represented by this difference. This is easy when dealing with whole magnitudes, but rather more difficult when stars differ by fractions of a magnitude. But logarithms help us out of the difficulty. The logarithm of 2·512 is 0·4, and we may raise 2·512 to any desired power by multiplying 0·4 by the index of the desired power, which gives us the logarithm of the desired power, and a reference to a table of logarithms will give the number corresponding to the logarithm so found, which represents the number of times the lower magnitude star is brighter than the higher magnitude star. Let us take a case. Regulus is of a magnitude represented by 1·34, Sirius is of a magnitude represented by − 1·58 (Miss Clerke). Subtract −1·58 from 1·34 and we get 2·92. Multiply 2·92 × 0·4, the logarithm of 2·512, the light ratio, and we have 1·168, and this is the logarithm of 14·72, so that Sirius is 14·72 times as bright as Regulus. It should be clear then that the actual difference in brightness between two stars is much greater than it appears to the naked eye, for the eye is not impressed in proportion to the actual difference, but only in proportion to the logarithm of that difference, or, to put it differently, stars which to the eye appear to form an arithmetical progression in brightness, in reality form a geometrical progression. This will explain why a photographic tyro is so often deceived in the photographic value of the evening light. His eye may tell him that the light is approximately midway between two known standards, and therefore he may decide on an exposure, say, of double that he would give under the brighter standard, while in reality the actinic value may be so much lower that eight times the exposure is necessary to proportionately affect the plate.

The problem of stellar photometry is not an easy one, as there are so many difficulties in the way of getting uniform conditions for observing. For instance, in the country stars look much brighter than they do in the city, and on a mountain brighter than they do in the level country. W. H. Pickering also thinks the seeing is much better nearer the equator than in the temperate zones. Stars near the zenith also appear brighter than when near the horizon, and as some stars to an observer in a given station never rise far above the horizon his observations will give a lower value to the brightness of such stars than if they were observed near the zenith. Thus observations of star magnitudes must have a correction applied reducing them to standard distance above the horizon, if they are not observed under similar conditions. Further, eyes differ in their sensitiveness to light, and thus one observer may get results different from hose of another.

The color of a star also may affect the results as some eyes are more sensitive to one color than another. Another curious thing is that if we take a green light and a red light of equal intensity, and either double or halve the intensity, they will no longer appear equal to the eye. When the intensity of both is doubled the red will appear the brighter, and when halved the green will appear the brighter. It is also to be remembered that the atmospheric absorption for the different parts of the spectrum is not the same. When all these things are considered it is no wonder that the photometric determinations of different observers vary.

It will be interesting, I think, to consider the number of the stars of different magnitudes. Here again doctors differ, but I have used the figures given by Todd (1897) :— I. = 20, II. = 65, III. = 200, IV. = 500, V. = 1400, VI. = 5000, total 7185. The number increases up to the tenth magnitude by a sort of rough geometrical progression, the stars of a given magnitude being from 3 to 3·75 times more numerous than those of the next higher (*i. e.*, brighter), so that there are about 720,000 stars of the tenth magnitude. After that the ratio decreases so that it is

probable that in the first 16 or 17 magnitudes there are not more than about 100,000,000 stars. Rockefeller has more dollars than that.

A study of the total light-giving power of stars of the different magnitudes reveals some unexpected results. It will be remembered that the brightness of stars of different magnitudes increases in a geometric progression, 2·512 being the ratio; but the number of the stars of the different magnitudes, from the first downwards to 10, increases as above stated in a geometric progression in which the ratio is from 3 to 3·75, consequently as the magnitude decreases the total light increases. One curious result of this is that we get more than twenty times as much light from stars we cannot see with the naked eye as from those we can see.

The estimates of the total light received from the stars vary widely. Newcomb's experiments would put it in the neighborhood of about $^1/_{80}$ of the light of the full moon. Professor Young puts it as high as $^1/_{60}$. Newcomb's estimates up to the tenth magnitude are interesting and I shall quote them. Taking the light of all those of the first magnitude as unity, 1st magnitude = 1; 2nd = 1·4; 3rd = 2; 4th = 2·8; 5th = 4; 6th = 5.7; 7th = 8; 8th = 11·3; 9th = 16; 10th = 22·6.

Stars from magnitudes 1 to 6 are naked eye stars, and their proportion of the total light is 16·9 units, only about $^1/_5$ of the total light up to the 10th magnitude.

As we estimated that the naked eye stars give about $^1/_{20}$ of the total light received from all the stars and the stars down to the 10th magnitude give five times as much, it is evident that all the stars must give four times the light of those down to the 10th magnitude, and consequently the stars below the 10th magnitude give three times as much light as those from 1st to 10th.

It is very clear then that we would not suffer a very serious diminution of sky light at night if all the stars that delight our unaided eyes were blotted out, while the extinction of the telescopic and photographic stars would be a very serious deprivation. Another instance, by the way, of the importance of unseen

things. Who can say but that higher senses or a better development of our present senses might not reveal other and more important unseen influences than the light of the stars.

I might say in parody of Hamlet "There are more things in Heaven and earth Horatio than are seen by your astronomers."

I need say little about the ordinary methods of observing star magnitudes.

One is by naked eye comparison, but more important scientifically are the extinction method by means of a wedge of neutral-tinted glass, and the equalization method in which the polariscope is employed.

The photographic method is less employed and being also less well known deserves fuller mention.

Photography has been probably the most important of the sister arts or sciences which have been pressed into the service of astronomy. It has enabled the astronomer to penetrate into the depths of space far beyond the ken of our largest visual telescopes; it has made possible the charting of the heavens in a manner impossible by the laborious method of visually observing and charting individual stars, and now it comes to our aid in stellar photometry.

When, however, we consider that what *we* see in a star and what a sensitive dry plate sees are quite different things, it is at once evident that photographic magnitudes are not always strictly comparable with visual magnitudes.

The blue end of the spectrum and the ultra-violet most affect a dry plate, while our eyes give greater value to the orange and red end of the spectrum, and it is impossible to make our plates exactly take the place of eyes even by the use of colored screens and orthochromatic plates. Still photographic estimations of the stellar magnitudes have their value since the results in the case of bright stars follow very closely the visual estimates and in any case we have a record of the relative standing of the stars observed as regards the blue and ultra-violet rays they emit.

Photographic magnitudes are estimated in different ways. The first is by observing the effects of irradiation. To make this method clear to you consider an analogy.

If I throw a small stone into a pool of soft mud it will make a little splash. If I throw in a large stone it will make a big splash, and stir up the mud in a much wider circle than did the little one. Now weak light and strong light produce much the same effect on a photographic plate as did the stones on the mud.

Most view-photographers have had good pictures of interiors spoiled by the strong light from some window making a "halo" round about the window frame. A point of light from a star acts in the same way, and if the exposure is long enough the light is reflected from particle to particle of the emulsion in such a way that the star image is enlarged to a circle. It is evident that bright stars make a greater splash, as it were, on the plate than faint stars, and so by measuring the diameters of these images we can estimate the relative photographic magnitudes of the stars that made them.

Another plan is to move the plate slightly inside the focus of the lens, giving the star the appearance of a luminous disc. The luminosity of these discs will vary, of course, with the brightness of the stars observed, and by measuring the opacity of the silver deposits formed on the plate the relative magnitudes of the stars observed may be estimated. (See *Astrophysical Journal*, November, 1907, p. 253).

The usual method of observing is to photograph the desired stars when they are at the altitude of the pole and then on the *same* plate, and with the same exposure photograph the pole star and a certain sequence of standard stars around it. The standard stars and stars to be observed are easily identified by taking separate photographs of each, superimposing these on the double-exposed plate and marking the desired stars. The double-exposed plate may now be examined and the magnitudes of the observed stars estimated by comparison with the stars of the standard sequence.

Attempts have been made to secure an absolute scale of photographic magnitudes. You will have noticed that in the above method the magnitudes are obtained by comparison with stars of previously determined magnitudes. This is not always a very convenient method, and besides some day our standards

may have changed their brightness. If, therefore, we can adopt a standard of comparison which can at any time be reproduced by laboratory experiments a great advance has been made, for any observer in the distant future can always compare our determination of magnitudes with his own, as the possession of the data is all that is necessary to the reproduction of the standard.

Messrs. Parkhurst and Jordan, of the Yerkes Observatory, have recently tried a method of obtaining absolute magnitudes with much success.

Their process was to illuminate different parts of a photographic plate with the light passing through a number of holes varying in size in a regular ratio and representing differences in illumination expressible in stellar magnitudes. Plates such as shown in the *Astrophysical Journal*, November, 1907, were thus produced. By comparing such plates with one of Pickering's photographic wedges the absorption curve of the wedge could be plotted and the wedge scaled in stellar magnitudes. Star images are then photographed out of focus and the plates compared in a photometer with the wedge and the magnitudes of the stars determined according to the effect their light had had on the plate. The effect of the stars on the plate is thus comparable with the light passing through holes of different diameters.

This sounds quite simple, but in that it is like a great many other astronomical observations, which are very simple if only rough approximations to accuracy are required but which require all the refinements ingenuity can suggest to avoid or eliminate errors and secure those finely accurate results which modern astronomy demands.

The originators of this method deem it useful for the measurement of light curves of variables of the Algol type and of short period variables generally.

In this article the treatment of the subject has necessarily been general rather than specific as my aim has been to give as complete an outline as possible of the whole subject and to bring together general information now unobtainable by the amateur except by reference to a considerable number of standard works and scattered papers.

SOME PRELIMINARY RESULTS DEDUCED FROM OBSERVED RADIAL VELOCITIES OF STARS*

By W. W. Campbell

UP to January 1, 1910, the radial velocities of 1020 stars had been determined with the Mills spectrographs at Mt. Hamilton and at Santiago, not counting about 100 stars whose velocities are variable and not yet investigated. Published velocities were collected also for 40 stars observed with spectrographs at other observatories and not with the Mills spectrographs. Adding 13 results for nebulæ obtained by Keeler, using visual methods, we have a total of 1073 radial velocities available for the solution of certain fundamental problems of the stellar system. With the assistance of all my colleagues, preliminary solutions of many problems were made prior to January 20, 1910, and below are given some of the results, as included in the Silliman Lectures delivered in Yale University, between January 24th and February 2nd, 1910.

The computed position of the Apex of the sun's way was

$$A = 272°{\cdot}0 \pm 2°{\cdot}5$$
$$D = +27°{\cdot}5 \pm 3°{\cdot}0$$

The corresponding velocity of the solar motion was found to be

$$V = 17{\cdot}8 \text{ km. per second.}$$

The smallness of this value of the velocity was surprising, in view of my earlier and other recent higher values, but the data of observation employed cannot be made to yield a sensibly greater value. Assuming the position of the Apex as defined above, the velocity of the system was determined anew by taking the arithmetical mean of the velocity afforded by each observed star, due regard being given to the angular distance of each star from the Apex. 330 stars of spectral types *O*, *B*, *A* and *F* to *F*4 yielded a value.

*Abstract of a paper presented at the Boston meeting of the Astronomical and Astrophysical Society of America, August, 1910.

$$V = 17{\cdot}7 \text{ km.}$$

704 stars of spectral types $F5$ to G, K and M yielded a value

$$V = 18{\cdot}0 \text{ km.}$$

The 13 nebular velocities were used in determining the first value of V, but not in determining the second and third values.

In problems referred to below, the velocities have first been freed from the solar motion component.

The radial velocities of the stars plotted with reference to the numbers of stars having certain observed values follow closely the law of accidental errors.

The stars were tabulated with reference to their visual magnitudes and observed radial velocities, taking account of spectral types, with the following general results:

1. The radial velocities do not appear to be a function of the visual magnitudes.

2. The stars of late-type spectra, $F5$ to M inclusive, 705 in number, have observed radial velocities very nearly 50 per cent. greater than the stars of early-type spectra, O to $F4$ inclusive, 330 in number.

Tabulating the observed velocities with reference to the five divisions of spectra types, O and B inclusive, A, F, G to K inclusive, and M, it appears probable that the velocity of a star is a function of its spectral type, for the velocities increase constantly with advancing spectral type, from 9·0 km. for the average of 141 O and B types up to 16·5 km. for the mean of 72 M types. The mean velocity for the 13 nebulæ is 23·4 km.

Kapteyn's theory of a systematic drift of the stars was confirmed, as follows:

Assuming the position of the vertex of the drift to be at $\alpha = 93°$, $\delta = +12°$, the angular distances of the observed stars from the vertex were computed and tabulated, first in 18 zones 20° wide and later in 6 zones 30° wide. If the stars have a preference for motion toward and away from the vertex, the radial velocities of stars nearest to and furthest from the vertex should exceed the velocities of the stars 90°, more or less, from the vertex. This tendency is clearly and strongly evident in the results.

The radial velocities of stars at and opposite to the vertex appear to be about 33 per cent. greater than the velocities of stars situated 90° from the vertex.

In making the observed radial velocities and their proper motions to correspond, the following results are strongly indicated :

1. The stars of different magnitudes are more thoroughly mixed, that is, are more nearly equal in distance, than has hitherto been supposed.

2. All magnitudes down to the 5th, and especially the brighter magnitudes, are further away than the formulæ for mean parallaxes have placed them.

3. The parallax stars which have been used as sample stars are not representative of the stars in general.

It is planned to make another solution soon, now that Boss's proper motions are available, and some of the results quoted above may be changed.

A systematic study of spectroscopic binary stars led to many interesting and apparently important conclusions, chief of which were :

1. The period of revolution is a function of the spectral type ; short in general for early types, and long in general for late types.

2. The eccentricity is a function in general of the period of revolution, and therefore of the spectral type ; the orbits of the short-period early-type binaries are in general nearly circular, whereas those of the long-period late-type binaries are in general very eccentric.

The orbits of about 70 spectroscopic binary systems known to date with reasonable accuracy afford confirmation to the theoretical conclusions of Darwin, Poincaré and See, as to the origin and development of binary stellar systems.

Other deductions from statistical studies of stellar velocities, and concerning binary systems, are not here described, from lack of space.

THE MOUNT WILSON CONFERENCE OF THE SOLAR UNION

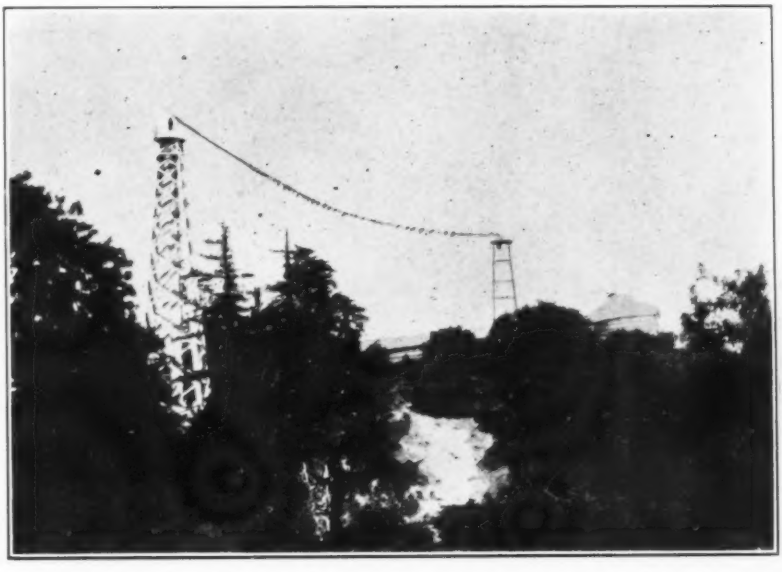
By C. A. Chant

Origin and Former Conferences

THE International Union for Co-operation in Solar Research is only six years old, but it is certainly one of the most active and inspiring of scientific organisations. For many years astrophysicists in various parts of the world had pursued their investigations upon the sun and the other heavenly bodies, and although the published work of one gave the others some information regarding what was being accomplished, yet there was no attempt at co-operation in attacking the many great problems awaiting solution. The feeling that there should be some kind of united action led Professor George E. Hale, then director of the Yerkes Observatory as well as of the newly-established Carnegie Solar Observatory on Mount Wilson, to address a circular letter to a number of men of science, asking their views on the matter. All the replies were favorable to action looking to some co-operative union, and Professor Hale then approached various societies and academies, requesting them to appoint committees for the purpose of initiating the proposed organisation.

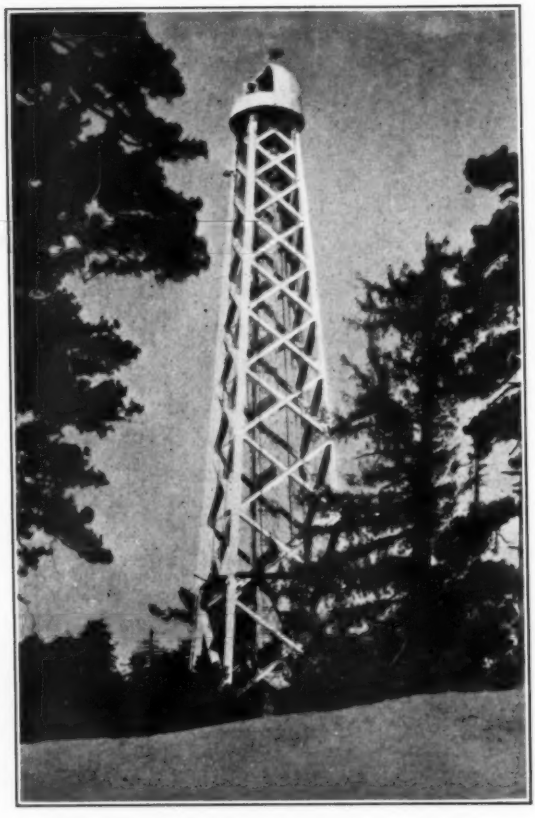
In carrying out the proposal the National Academy of Sciences (of the U.S.A.) named the following as a Committee on Solar Research :—George E. Hale (Chairman), W. W. Campbell, S. P. Langley, A. A. Michelson and C. A. Young. This committee was authorised to co-operate with other committees in arranging plans for solar research. Invitations were then extended by the committee to the various societies and institutions to appoint committees on solar research, and to send one or more representatives to a general meeting to be held in connection with the International Congress of Science convened at the time of the St. Louis Exposition.

THE MOUNT WILSON HOTEL (5880 feet altitude)

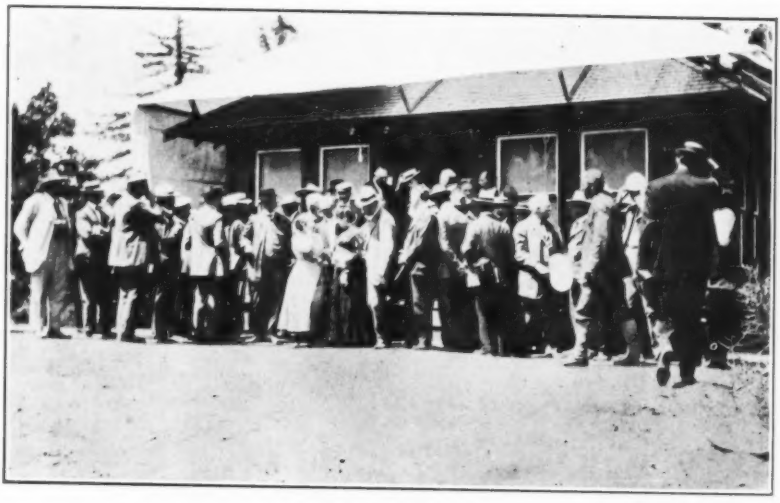


THE 150-FOOT AND 60-FOOT TOWER TELESCOPES AND THE HORIZONTAL TELESCOPE. Looking east from the Hotel.

PLATE XXIII.



THE 150-FOOT TOWER TELESCOPE



FRIENDLY GREETINGS AFTER THE FIRST SESSION

A BATTALION OF PHOTOGRAPHERS IN ACTION AFTER THE FIRST SESSION

Puiseux Deslandres Fabry

A FRENCH GROUP

Hills Turner Schuster Hale Ellerman (behind Schuster)

A GROUP, AFTER THE FIRST SESSION

Journal of the Royal Astronomical Society of Canada, 1910

At this meeting, which was held on September 23, 1904, there were present sixteen delegates, representing fourteen societies and nine distinct countries. Professor Hale outlined a plan in which were combined the encouragement of original ideas of individuals and co-operation for the accomplishment of certain pieces of work. Several papers were presented, dealing with the question of standard wave-lengths and showing the necessity for immediate action so as to bring order out of the chaos caused by the discovery that Rowland's classical measurements were vitiated by several, though small, errors.

The next Conference was held at Oxford, England, September 27-29, 1905, twenty-two elected delegates and eighteen other scientists being in attendance. The chief subjects discussed and reported upon by committees were standards of wave-length, spectroheliographic work and the intensity of solar radiation.

The Constitution of the Union was also formally adopted. It provides that the Union shall consist of scientific bodies interested in the progress of solar research, each constituent body acting through a committee nominated by it for the purpose. Each member of the committee is a member of the Union. The International Committee is organised through the election of one member by each constituent body, and the Executive Committee consists of three members of the International Committee. Questions of organisation and administration are discussed and settled by the International Committee, while scientific questions are discussed by all the members of the Union.

The third Conference was held at the Astrophysical Observatory, at Meudon (near Paris), May 20-24, 1907, with an attendance of seventy-seven, representing thirteen countries. At this meeting some slight amendments to the Constitution were made, and the reports of committees showed that great progress was being made in the determination of standard wave-lengths, in the measurement of solar radiation, in work on sun-spot spectra and with the spectroheliograph and in other problems relating to the sun.

FOURTH CONFERENCE, AUGUST 31–SEPTEMBER 2, 1910

The fourth Conference was held on the summit of Mount Wilson, Cal., where is located the great solar observatory of the Carnegie Institution of Washington, the sessions continuing from August 31 to September 2.

Acting on a suggestion by Professor Hale, that Canada be represented in the Union, the Council of the Royal Astronomical Society of Canada some time ago applied for membership. The application was supported by the National Academy and the Royal Society and was unanimously approved. The Bologna Royal Academy of Science was also elected a constituent society, so that at present the Union is composed of twenty-two societies. It is a truly international organisation, and among its members are the most distinguished astrophysicists of the world.

The following members were in attendance :—

Professor J. S. Ames,	Johns Hopkins University,	Baltimore, Md.
Mr. Charles G. Abbot,	Smithsonian Astrophysical Observatory,	Washington, D. C.
Mr. Walter S. Adams,	Mt. Wilson Solar Observatory,	
Mr. Harold D. Babcock,	Mt. Wilson Solar Observatory,	
Professor J. O. Backlund,	Observatoire de Poulkovo,	Poulkovo, Russia.
Professor E. E. Barnard,	Yerkes Observatory,	Williams Bay, W.s.
Professor A. Belopolsky,	Observatoire de Poulkovo,	Poulkovo, Russia.
M. Jean Bosler,	Observatoire de Meudon.	Meudon, France.
Professor F. P. Brackett,	Pomona College,	Claremont, Cal.
Miss Cora G. Burwell.	Mt. Wilson Solar Observatory,	
Profestor W. W. Campbell,	Lick Observatory,	Mount Hamilton, Cal.
Professor C. A. Chant,	University of Toronto,	Toronto, Canada.
M. Henri Chretien,	Observatoire de Nice,	Nice, France.
Rev. R. Cirera, S. J.,	Observatorio del Ebro,	Tortosa, Spain.
Dr. W. W. Coblentz,	Bureau of Standards,	Washington, D. C.
Rev. A. L. Cortie, S. J.,	Stonyhurst College Observatory,	Lancashire, England.
M. A. Cotton,	Ecole Normale Superieure,	Paris, France.
M. H. Deslandres,	Observatoire de Meudon,	Meudon, France.
Professor N. Donitch,	Observatoire de l'Universite,	St. Petersburg, Russia.
Mr. Frank L. Drew,	Mt. Wilson Solar Observatory,	
Professor F. W. Dyson,	Royal Observatory,	Edinburgh, Scotland.
Mr. Ferdinand Ellerman,	Mt. Wilson Solar Observatory,	
Dr. P. Eversheim,	University of Bonn,	Bonn, Germany.

Professor Charles Fabry,	Universite de Marseilles,	Marseilles, France.
Dr. Edward A. Fath,	Mt. Wilson Solar Observatory,	
Mrs. W. P. Fleming,	Harvard College Observatory,	Cambridge, Mass.
Mr. F. E. Fowle,	Smithsonian Astrophysical Observatory,	Washington, D. C.
Professor A. Fowler,	Imperial College of Science and Technology,	South Kensington, London, England.
Professor Philip Fox,	Dearborn Observatory,	Evanston, Ill.
Professor E. B. Frost,	Yerkes Observatory,	Williams Bay, Wis.
Dr. Henry G. Gale,	University of Chicago,	Chicago, Ill.
Professor L. H. Gilmore,	Throop Polytechnic Institute,	Pasadena, Cal.
Miss Clementina D. Griffin,	Mt. Wilson Solar Observatory,	
Professor George E. Hale,	Mt. Wilson Solar Observatory,	
M. M. Hamy,	Observatoire de Paris,	Paris, France.
Professor J. Hartmann,	Koenigliche Sternwarte,	Göttingen, Germany.
Professor K. Hausmann,	Technische Hochschule,	Aachen, Germany.
Prof. J. v. Hepperger,	Imperial Observatory,	Vienna, Austria.
Major E. H. Hills,	32 Prince's Garden,	London England.
Prof. W. J. Humphreys,	U. S. Weather Bureau,	Washington, D. C.
M. Idrac,	Observatoire de Meudon,	Meudon, France.
Professor J. C. Kapteyn,	Astronomical Laboratory,	Groningen, Holland.
Professor H. Kayser,	University of Bonn,	Bonn, Germany.
Dr. Arthur S. King,	Mt. Wilson Solar Observatory,	
Professor H. Konen,	Physikalisches Institut,	Münster, Germany.
Professor F. Küstner,	Koenigliche Sternwarte,	Bonn, Germany.
Mr. C. O. Lampland,	Lowell Observatory,	Flagstaff, Ariz.
Sir Joseph Larmor,	Royal Society,	London, England.
Miss Jennie B. Lasby,	Mt. Wilson Solar Observatory,	
Professor A. O. Leuschner,	University of California,	Berkeley, Cal.
Professor H. C. Lord,	Emerson McMillin Observatory,	Columbus, Ohio.
Professor A. G. McAdie,	U. S. Weather Bureau,	San Francisco, Cal.
Dr. Walter M. Mitchell,	Detroit Observatory,	Ann Arbor, Mich.
Professor H. F. Newall,	University Observatory,	Cambridge, England.
Mr. F. G. Pease,	Mt. Wilson Solar Observatory,	
Professor E. C. Pickering,	Harvard College Observtory,	Cambridge, Mass.
J. S. Plaskett, Esq.,	Dominion Observatory,	Ottawa, Canada.
Comte A. de la Baume Pluvinel,	7 Rue de la Baume,	Paris, France.
Professor E. Pringsheim,	University of Breslau,	Breslau, Germany.
Professor P. Puiseux,	Observatoire de Paris,	Paris, France.
Professor A. Ricco,	Osservatorio astrofisico,	Catania, Sicily.
Professor G. W. Ritchey,	Mt. Wilson Solar Observatory,	
Professor A. L. Rotch,	Blue Hill Observatory,	Hyde Park, Mass.
Dr. Henry Norris Russell,	Princeton University,	Princeton, N. J.
Professor J. R. Rydberg,	University of Lund,	Lund, Sweden.
Dr. Charles E. St. John,	Mt. Wilson Solar Observatory,	
Prof. Fernando Sanford,	Leland Stanford, Jr. University,	Palo Alto, Cal.

Dr. Frank Schlesinger,	Allegheny Observatory,	Allegheny, Pa.
Professor Arthur Schuster.	Victoria Park,	Manchester, England.
Professor K. Schwarzschild,	Astrophysikalisches Observatorium,	Potsdam, Germany.
Professor F. H. Seares,	Mt. Wilson Solar Observatory,	
Dr. V. M. Slipher,	Lowell Observatory,	Flagstaff, Ariz.
Professor Fred. Slocum,	Yerkes Observatory,	Williams Bay, Wis.
Miss Ruth E. Smith,	Mt. Wilson Solar Observatory,	
Professor S. W. Stratton,	Bureau of Standards,	Washington, D. C.
Professor H. Struve,	Koenigliche Sternwarte,	Berlin, Germany.
Professor S. D. Townley,	Leland Stanford, Jr. University,	Palo Alto, Cal.
Professor H. H. Turner,	University Observatory,	Oxford, England.
Miss Louise Ware,	Mt. Wilson Solar Observatory,	
Miss Pheobe Waterman,	Mt. Wilson Solar Observatory,	
Professor F. R. Watson,	University of Illinois,	Champaign, Ill.
Professor H. C. Wilson,	Goodsell Observatory,	Northfield, Minn.
Professor A. Wolfer,	Sternwarte des Eidgenossischen Polytechnikums,	Zurich, Switzerland.

Mr. Plaskett, of Ottawa, and the writer attended as delegates from the Royal Astronomical Society of Canada.

An analysis of the table shows the following geographical distribution of the members:—United States, 46; France, 9; Germany, 9; Great Britain, 8; Russia, 3; Canada, 2; Austria, Holland, Italy, Spain, Sweden and Switzerland, 1 each. Total, 83.

Many of the members had been in attendance at the meeting of the Astronomical and Astrophysical Society of America, held at the Harvard College Observatory, Cambridge, Mass., August 17 to 19; and had crossed the continent on a special train, which arrived in Pasadena on Sunday, August 28. The others went by various routes and all gathered at headquarters, which were at the beautiful Hotel Maryland.

The morning of Monday, August 29, was devoted to an inspection of that portion of the Solar Observatory located at Pasadena. Here are the offices, the extensive machine and instrument shops and the physical laboratory. The shops contain a complete equipment of wood, machine and instrument tools and grinding machines for the figuring of lenses and mirrors up to 100 inches in diameter. One of the interesting features was the large machine built to grind the great 100-inch mirror,

for the construction of which Mr. J. D. Hooker, of Los Angeles, is supplying the means. Near by is the immense disc of glass, 100 inches in diameter, 13 inches thick and weighing 4½ tons, which was received from France some time ago, but which proved unsuitable for the immense mirror. It was cast in three layers, and although when used as a mirror in a telescope the light is reflected only from the outer surface, still it was feared that on account of the lack of homogeneity the great disc would not preserve its figure. Further attempts are being made in France to produce a disc more uniform and, perhaps, a little thicker, but the date when it will be ready is very problematical. It is over three years since the original order was given.

In the physical laboratory some of the chief instruments are for experiments at high temperatures and pressures. When, upon analysing the sun's radiation, a result is obtained, an effort is made to reproduce it by artificial means in the laboratory. If it can be done a clue is at once offered to explain the solar phenomena. There are also several fine instruments for the measurement of photographic plates. and a quantity of minor apparatus.

At 4 p.m. there was a garden party at Hermosa Vista, the charming home of Professor and Mrs. Hale. This was largely attended by the visiting scientists, many of them accompanied by other members of their families, and by many distinguished residents of Pasadena. It was a very enjoyable function.

On Tuesday the scene was changed to Mount Wilson. There are two routes to the summit: (1) By electric car to the foot and then by saddle horse or on foot, over the Old Trail. (2) By carriage via the Mount Wilson Toll Road. This latter is only eight feet wide and was constructed for the transport of the heavy instruments and supplies for the Observatory at a cost of about $50,000. Although the summit has an elevation of only about 5800 feet and the entire climb is less than ten miles in length, yet the passage up proved to be quite an undertaking. The gradient is very steep and as the turns are very short it was not expedient to attach more than one team of horses to each

carriage in which there were usually six passengers. A halt of one hour was made for refreshment and the stops to rest the horses were numerous. In this way over eight hours were consumed in the trip and everyone on reaching the top was tired and covered with a thick layer of dust.

Accommodations had been reserved at the Mount Wilson Hotel, which was taxed to its limit, many having to sleep in tents. After a general cleansing and a short rest the difficulty of the ascent was soon forgotten. The changing landscape on the way up and the views from the summit were simply delightful; while at night the stars shining with extraordinary brilliance in a clear sky above and the multitude of electric lights in Pasadena, Los Angeles and the smaller towns in the valley below presented a picture which will not soon be forgotten.

Wednesday, August 31

The official sessions of the Conference began at 9.30 a.m. Wednesday, August 31. On motion of Professor Schuster Directors Pickering (of Harvard), Campbell (of Lick), and Frost (of Yerkes) were chosen chairmen for Wednesday, Thursday and Friday, respectively; and Messrs. Puiseux (of Paris), Konen (of Münster) and Adams (of Mount Wilson) were made French, German and English secretaries, respectively. Mr. Babcock was assistant secretary.

Professor Hale extended a hearty welcome to the astronomers and physicists who had gathered from all parts of Europe and America, and expressed the view that the Union was more useful for stimulating research by personal contact in meeting together and entering into discussion rather than by the presentation of formal papers or even by formal co-operation.

He then described the new Tower Telescope now in course of erection. It consists of a great steel tower 150 feet high, but a peculiarity of its construction is that the supporting pillars and the braces between them which one sees are hollow and contain within them another tower in no place in contact with the first, and supported on entirely separate foundations. In this way

the inner tower is protected from the wind and also from the direct sunlight, and so is extremely rigid and steady. At its top it supports a lens 12 inches in diameter and of 150 feet focus. The sunlight is direted through this by being reflected from a mirror above moved by clockwork, and it forms a solar image at the base of the tower 16 inches in diameter. This is large enough for a minute study of any portion of the disc.

Under the tower is a well nearly 80 feet deep in which will be placed a combined spectrograph and spectroheliograph of 30 or 75 feet focus, to be provided with prisms and gratings giving a wide range of dispersion. The instrument will be completely equipped with polarizing apparatus for the study of magnetic fields in sunspots, and with apparatus for photography of the spectrum of the chromosphere and centre and limb, and for the study of solar rotation.

The object of the deep well is to protect the instruments within it from the great changes of temperature experienced on Mount Wilson and which destroy the definition of any delicate instrument exposed to them. The great success of the 60-foot tower telescope erected three years ago led to the construction of this much greater one.

When completed the adjustments at the top of the tower and down in the well will be made by electric motors controlled from the ground, thus avoiding climbing to the top or descending to the bottom. It was intended to have a small elevator in operation for allowing the visitors to ascend and inspect the arrangements above, but this could not be got ready; and the ascent was made by any one who desired it in a steel bucket drawn up by a hoisting engine. When at the top the outlook was somewhat startling and the rapid descent to the ground was equally so.

This was the only session of the Conference attended by Professor Hale, as he was suffering from indisposition brought on by over-work and perhaps, also, by his anxiety that the great gathering should be in every way a success.

Professor Schuster presented the report of the Executive

Committee. It referred to the loss to the Union by death, of Loewy, Hemsalech, Janssen, Young, Huggins, Hansky, W. E. Wilson and K. Angström. It also recommended the Union to urge that a solar observatory be established in Australia. (It is known that the Government of the Commonwealth is considering the question). It also stated that our Society and the Bologna Academy had been elected constituents of the Union. Further, statutes had been passed to allow the appointment on committees of persons who are not members of the body making the appointment.

On motion of Professor Turner a message of sympathy was sent to Lady Huggins.

Professor Kayser presented the report of the Committee on Determination of Standard Wave-lengths. Taking Michelson's determination of the wave-length of the red cadmium line by the interferometer as a primary standard, the report stated that numerous secondary standards had been determined by Fabry and Buisson at Paris, Eversheim at Bonn and Pfund at the Johns Hopkins University, Baltimore. A table containing 371 of these standard lines was presented for adoption.

After a brief discussion the following recommendations of the Committee were adopted.

RECOMMENDATIONS OF THE COMMITTEE ON WAVE-LENGTHS

1. In the region of the spectrum in which three independent measurements by the interferometer method of the lines of the iron arc are available, *i. e.* between λ 4282 and λ 6494, the arithmetical mean of the three measurements shall be adopted as definite international standards of second order, provided there is sufficient agreement between them.

2. The committee be given authority to publish these standards as soon as possible.

3. For the part of the spectrum in the neighborhood of λ 5800, where the number and character of the iron lines is not satisfactory, the committee proposes the use of barium lines as additional standards.

4. Laboratories or observatories possessing first-rate concave gratings are invited to determine by interpolation as soon as possible, standards of the third order in the spectrum of the iron arc within the above range, (*i. e.* λ 4282 to λ 6494).

5. The measurement of standards of the second order shall be extended to shorter and longer wave-lengths, and the arithmetical mean of three independent determinations shall be adopted as secondary standards.

6. Standards of the third order shall then be obtained in the manner indicated.

7. The above system of standards shall be called the International System, the unit on which it is based being called the International Unit (denoted I. A.) as defined by the conference of 1907.

8. It is very desirable that in different laboratories possessing concave gratings of the first quality, photographs of arc, spark and solar spectra and new measurements according to the International System shall be taken as soon as possible.

At a later session it was agreed that the plane grating and the auto-collimating spectrograph might also be used in measuring tertiary standards (see below).

In the evening Director C. G. Abbot, of the Smithsonian Astrophysical Observatory gave a lecture on the "Solar Constant of Radiation." He outlined the history of the subject, naming the varying values of the constant accepted at different times, and then gave a brief account of his own work. Mr. Abbot has been very anxious to obtain daily observations extending over a long period of time, in order to see if there is any fluctuation in the value of the constant, but so far only with partial success. It is very desirable that similar observations be made at the same time at a second station suitably located.

Thursday, September 1

The first business on Thursday morning was the report of the Committee on the Measurement of Solar Radiation, which was presented by Director C. G. Abbot. In recent years from numerous independent and concordant determinations made at the Smithsonian Astrophysical Observatory, at Washington and at Mount Wilson, the Solar Constant of Radiation has been found to be about 2·0 calories per square centimetre per minute; and the investigations are also thought to yield fairly well warranted indications of frequent variability of the order of 5 or 10 per cent. in the intensity of the solar radiation outside the atmosphere.

The report recommended investigations into the amount, distribution and spectral quality of the solar radiation which is diffusely reflected by the atmosphere, as our knowledge of sky radiation and cloudiness is quite unsatisfactory. Also, it was regarded as highly desirable that there should be obtained numerous records of the distribution of radiation over the sun's disc.

Information of others working to devise a trustworthy pyrheliometer was given. Callendar, of London, Eng., has arranged a form of Augström's instrument which he thinks very constant in its action. Marvin, of Washington, has also devised one of the electrical resistance type,— using a nickel ribbon,— which is being tested by practical observations.

Professor Pickering offered to have observations made at the Harvard station at Arequipa, Peru, if the proper instrument is available.

Professor Fowler presented the report of the Committee on the Spectra of Sunspots. According to Michie Smith the spectra of sunspots are as constant in nature as the ordinary Fraunhofer spectrum. Father Cortie said he had examined spot spectra for twenty years and he thinks them quite unchanged through periods of maximum and minimum sunspot activity.

The Conference adopted the following

RESOLUTIONS PRESENTED BY THE COMMITTEE ON THE SPECTRA OF SUNSPOTS

1. That the reports of the Committee and of the co-operating observers be printed in the transactions of the Union in full or in abstract as circumstances may determine.

2. That notwithstanding the photographic results, visual observations are desirable and the committee should be continued.

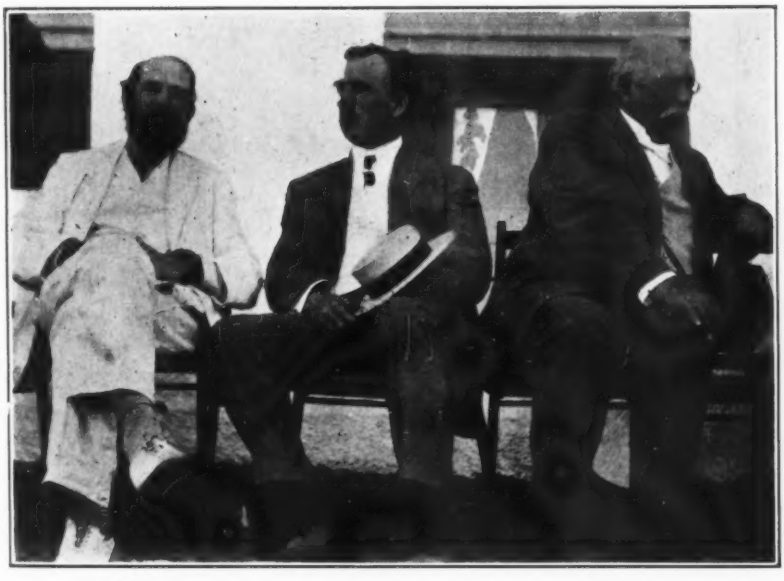
3. That the Committee be requested to prepare and circulate a revised scheme of observations.

4. In view of the fact that several observers have prepared catalogues of great numbers of sunspot lines, it is desirable that these results be collated.

5. It is desirable that the sections of the new map of the sunspot spectrum do not exceed 60 centimetres in length and be on a scale of 5 millimetres to one Angström.

Brackett Kapteyn Schwarzschild V. M. Slipher

A GROUP ON THE MOUNTAIN



Schuster Campbell Hooker

A GROUP AT THE "MONASTERY"

THE POSSESSOR OF AN INTERESTING "NOTE-BOOK" AT AFTERNOON TEA

AT AFTERNOON TEA, BEFORE THE "MONASTERY"

Professor Newall recommended that the plane-grating spectrograph be used for supplying standards between secondary standards, and in this he was supported by Messrs. Adams, St. John and Plaskett.

In the evening Professor J. C. Kapteyn, of Groningen, Holland, who has been spending some months at the Mt. Wilson Observatory, lectured on "Star-Streaming of Stars of the Orion Type." The lecture gave an interesting account of an investigation which he has made into the motions of the Orion stars; and in addition to being the record of a notable piece of work, the subject was presented in a very lively and pleasing manner and so was greatly enjoyed by the large number present. The Orion stars are included almost completely in two portions of the celestial sphere. The first extends from R. A. 12^h to 18^h and from Dec. $0°$ to $-60°$, containing 4500 square degrees, chiefly in Scorpio and Centaurus; the second extends from R. A. $2^h\,50^m$ to $4^h\,30^m$ and from Dec. $+15°$ to $+55°$, containing 1300 square degrees, chiefly in Perseus. Now Kapteyn finds that those Orion stars in the first division move in the same direction in space, and with the same velocity; while those in the second division also move as a single system though in a different direction and with a different velocity.

Friday, September 2

The report of the Committee on the Determination of Solar Rotation by Means of the Displacement of Spectral Lines was presented by Mr. Adams. The problem before the committee is a large one, namely, to determine the variation in the rate of the sun's rotation with respect to latitude, to different substances in the sun and also with respect to time. For instance, hydrogen and calcium at high level give different results from cyanogen at low level. The committee arranged that the entire spectrum should be divided amongst six workers, namely, Messrs. Belopolsky, Schlesinger, Newall, Adams, Plaskett and Dyson, while all will work on the small region $\lambda 4220$ to $\lambda 4280$ in order to check each other's results.

The report of the Committee on Spectroheliographic Work was presented by Professor Frost. It included separate reports from Lockyer (of London), Cirera (of Tortosa, Spain), Ricco (of Catania, Sicily), and of Fox and Slocum (Yerkes Observatory). Spectroheliographs are now in regular operation in observatories in various countries by which it is hoped to secure a daily record of the different vapors in the solar atmosphere at various levels.

On Friday afternoon an interesting discussion took place on the proposal to extend the field of the Union to include work on the spectra of the stars.

Professor Newall said that the work of Campbell, Kapteyn, Russell and others rendered the problem of discussing the types of stars as somewhat unsettled at present. He questioned the necessity of appointing a committee or of acting dogmatically in the matter of classification.

Professor Schuster said that the persons who are studying the sun are studying the stars as well. Also, there are some who have not joined with the Union because it is devoted only to the sun. The question of stellar classification should be considered by an international association and he thought it doubtful wisdom to call another into existence to do so. The natural course of events would, he believed, in the near future drive the Union to take up the question.

Professor Pickering thought there could be no objection to extending the work of the Solar Union, and that there would be great value in doing so.

Professor Turner referred to the Astrographic Chart. In 1900 it became clear that the scope of that work was naturally being extended. He thought that the two international organisations should fill the entire field of astronomy and astrophysics. He suggested that a committee be appointed to consider the question of stellar spectra.

Professor Schwartzschild moved that the Solar Union extend its sphere of activity so as to include astrophysics generally.

Professor Fowler stated that it was impossible to investigate

solar questions without reference to the work on the stars and he thought the Union should extend its field.

The motion was carried unanimously.

Professor Pickering explained how the notation of the Draper Catalogue came about. When the classification was begun at Harvard it was on purely empirical lines, like labelling the beasts in a zoo by one with little knowledge of zoology. The different classes were indicated by letters, and as the work proceeded and the knowledge of stellar spectra increased all the types were dropped except the six denoted by B, A, F, G, K, M.

The Conference passed the following resolution :

This Conference learns with pleasure that it is proposed to erect a Solar Observatory in Japan.

The question of the time and place of the next meeting was next discussed. Professors Kayser and Schwartzschild spoke in favor of Bonn, Germany ; Father Cirera advocated Barcelona, Spain ; and Professor Ricco favored Rome, Italy. It was decided to meet at Bonn in 1913, the exact date being left to the Executive Committee.

The rest of the afternoon was occupied in appointing committees and passing resolutions of thanks. The former committees were, for the most part, re-appointed, a few alterations being made in some cases.

To the committee on Solar Rotation Mr. Plaskett and three others were added.

The new Committee on Stellar Spectra consists of : Messrs. Pickering (Chairman), Schlesinger (Secretary), Adams, Campbell, Frost, Hale, Hamy, Hartmann, Kapteyn, Newall, Plaskett and Schwartzschild, with power to add to their numbers.

The members of the Executive Committee, Messrs. Hale, Schuster and Ricco were re-elected.

Professor Newall moved that the cordial thanks of the Union be tendered to Professor Hale for the great trouble and care taken by him to make the visit of the Solar Union to Mount Wilson a pleasant and profitable one.

On motion of Professor Fabry hearty thanks were tendered

to the staff of the Mount Wilson Observatory for their kindness and consideration extended to the visiting members. Reference was made to the different members, but especially to Professor Ritchey who remained in charge of the great 60-inch reflector all Wednesday and Thursday nights in order to show its powers to all. About the room in which the meetings were held were magnificent transparencies made from the unrivalled negatives taken with the telescope. Professor Fabry called attention to the unique position of Professor Ritchey as the designer, the constructor and the observer; "and," continued he, "are his triumphs not written upon the walls of his room?"

Major Hills proposed a motion of thanks to the ladies of the Observatory for providing the pleasant social meetings.

Professor Schuster moved that thanks be given to the secretaries, Messrs. Adams, Puiseux and Konen, and to the stenographer who had reported the proceedings.

Through Professor Frost the foreign delegates tendered thanks for their reception; and on motion of Professor Schwartzschild thanks were tendered the gentlemen who had acted as chairmen.

The Conference was then declared adjourned.

During our stay on the mountain the entire equipment of the Observatory was open to inspection. The operation of the Snow Horizontal Telescope, with spectroheliograph attached, and of the 60-foot Tower Telescope was observed by many; but perhaps the greatest interest was shown in the 60-inch reflector, which has proved to be such a perfect instrument. Various objects were shown by it, including the Hercules Cluster, the Trapezium in the Orion nebula, and the planet Saturn. On Friday night a spectroscope was attached. The observations were usually made with a Cassegrain combination, by means of which the telescope had a focal length of 100 feet, and a magnification of 600. The definition and the light-gathering power were simply marvellous. The view of Saturn was especially noteworthy, Professor Barnard and other veterans expressing the opinion that they had never seen its equal. The crape ring was

really a *prominent* feature. The shadow could be seen upon it and the ball was visible through it. A bluish patch was seen at the pole and a canary-yellow band across the ball near the equator. In the Trapezium the fifth and sixth components appeared like brilliant stars ; and while the brighter middle stars of the Hercules Cluster stood wide apart a new multitude of fainter ones were revealed in the depths between.

On Saturday morning we bade good-bye to the summit and took passage back to Pasadena. The carriages took only four hours, and though the dust was still as deep as ever the day was cool and the trip very enjoyable.

The closing function was a dinner given by Professor and Mrs. Hale at the Hotel Maryland to the members and those accompanying them, in all about one hundred. The proceedings were quite informal, but the preparations had been made with the greatest care and were simply perfect. The menu and the service were the best, and conversation about the small tables was very pleasant.

Out of consideration for Professor Hale's indisposition, and to the regret of many there was no toast list. Professor Kayser, who occupied the head chair, in a pleasing speech proposed the health of Professor and Mrs. Hale. He remarked that the newspapers had stated that there were in Pasadena "seventy-five wise men from the east," and he was sure that if the good wishes of the "wise men" availed anything Professor Hale would speedily be perfectly restored to rugged health. It would ordinarily be considered a great work for any person to organise one observatory of the first rank ; but Professor Hale, while still a young man, has to his credit the initiation and complete equipment of two of the greatest in the world. All rose to wish long life to our host and hostess.

Professor Hale's reply was brief but eloquent. He expressed the gratitude of Mrs. Hale and himself for the kind wishes. He valued above almost everything else the esteem and good will of his scientific brethren, and thought the personal mingling at meetings like the one just closed was of the greatest possible

benefit. The fraternisation of scientific workers in all countries showed how strong a bond can be established between different nations and must give to those striving to ensure international peace, encouragement to continue in their efforts.

The dinner broke up at 10.30, and after greetings and adieus in the lobby the gathering dissolved.

Next day the exodus began. Nearly all went northward and visited the Lick Observatory and the University of California at Berkeley (near San Francisco), while many visited other noted places along the coast before starting for the east.

All felt, I believe, that the Conference had been a great success, and the investigation of problems in astrophysics will certainly proceed with renewed interest.

THE ASTRONOMICAL AND ASTROPHYSICAL SOCIETY OF AMERICA

By J. S. Plaskett

THE eleventh meeting of the Society was held at Harvard College Observatory on August 17, 18, 19. This particular date, two weeks before the Mt. Wilson meeting of the International Union for Coöperation in Solar Research, was chosen to enable the European members of the Solar Union to attend the Harvard meeting before journeying across the continent. The meeting was, on account of having so many distinguished European astronomers present, the most notable yet held; and was also probably the most successful so far as the number and quality of the papers presented was concerned.

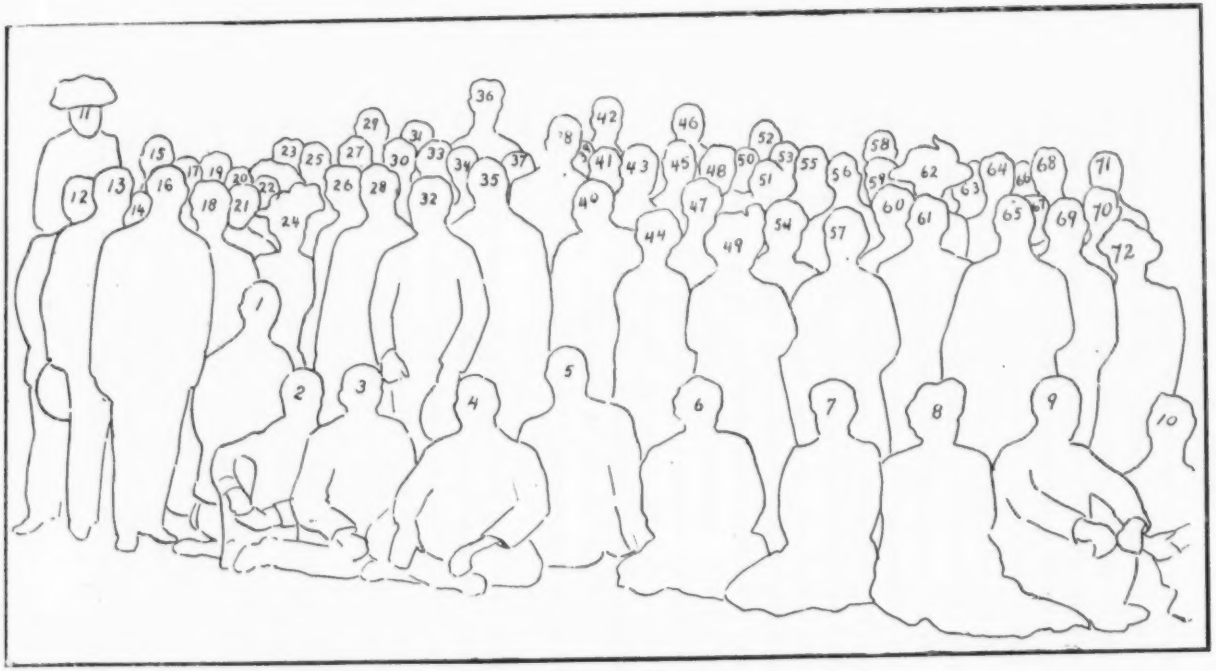
On the invitation of the Director, E. C. Pickering, President of the Society, the headquarters were at Harvard Observatory, all the morning sessions being held in a suitable room supplied with blackboard and other necessaries in the Director's residence. In this connection I would like to express my appreciation, shared I am sure by every member present, of the very hospitable and kindly way in which we were entertained and made to feel at home. The Director and his staff vied with one another in placing the whole resources of the observatory at our disposal, and in giving us some slight insight into the great work being done here.

A very attractive programme had been provided in which the usual strenuous nature of the proceedings of this Society, consisting of the reading of papers morning, afternoon, and night in some cases, was pleasantly varied and interrupted by excursions to points of interest in the neighborhood of Boston.

The morning of Wednesday, August 17, was devoted to the introductory business of the meeting and the reading of papers. After lunch, provided by the kindness of Director Pickering, the

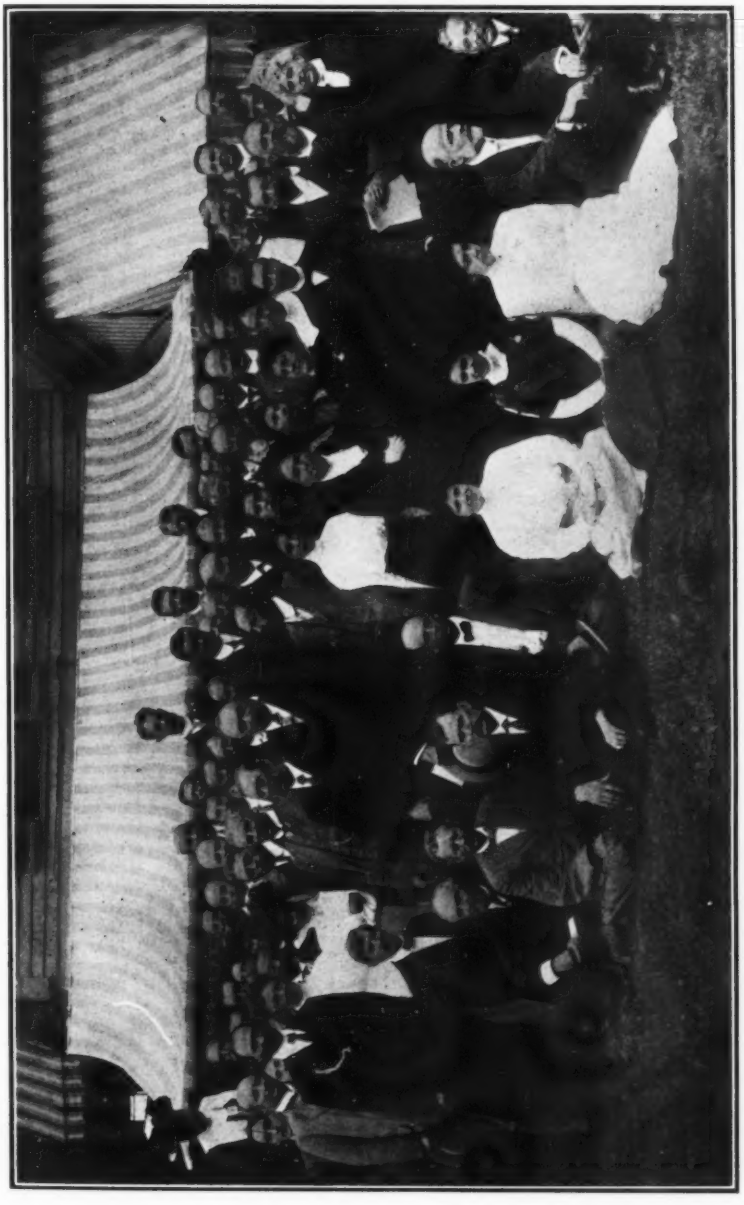
whole party proceeded by a special street car to the Blue Hill Meteorological Observatory, where a pleasant and instructive hour was spent in examining their methods of work. Much interest was evinced in the famous box kites and other original devices of the Observatory. On Thursday morning, besides the reading of papers for three hours, the nomination of officers, which has been somewhat simplified over the previous cumbrous procedure, occupied the attention of the meeting. An hour and a half of the afternoon, lunch being provided by the same kind foresight, was spent in examining the instruments, methods, and examples of work of the Harvard Observatory. Much admiration for the varied character and enormous amount of work done was expressed by the visitors. As aptly put by one member, there were very few papers read before the Society which could not be, even if they were not, compared with or referred to work along a similar line recorded in the *Harvard Annals*. A special car was in waiting at three o'clock to convey the party to Wellesley College, where they were hospitably entertained by the Staff in Astronomy. The many original and ingenious methods of teaching astronomy were explained and the equipment shown, and afterwards the members were driven around the beautiful Wellesley grounds.

The reading of papers was varied on Friday morning by the election of officers. Not much excitement was furnished, however, as the whole cabinet was re-elected, at which the Society is to be congratulated, as it would be difficult to find a more able and genial President and more efficient officers than it now possesses. At this session nearly all the papers not requiring lantern illustrations were read. The remaining papers were read, by the invitation of Professor Willson, at the Students' Astronomical Laboratory of Harvard University. After a reception and luncheon by the Director and Mrs. Willson, the work of the laboratory, with the many ingenious and helpful aids in teaching astronomy, was explained. The most striking of these was a representation on a large scale of the field of a transit instrument with an artificial star moving across the wires uniformly. The

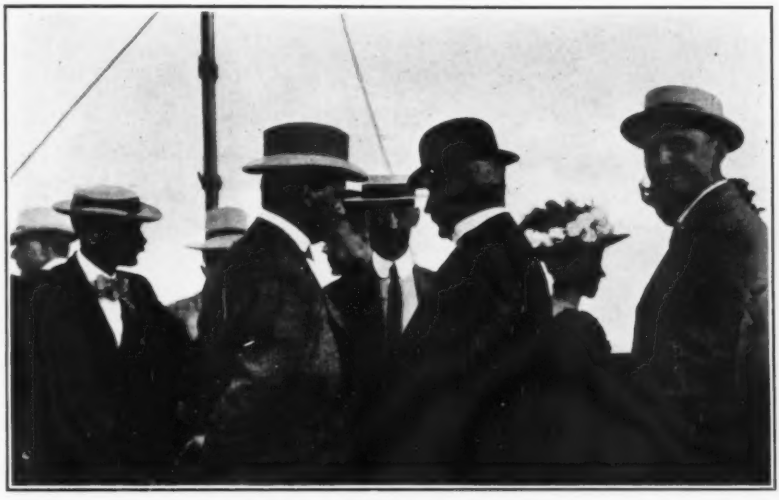


Key to Plate XXVIII.

1 L. Campbell
2 W. Upton
3 F. W. Very
4 W. J. Hussey
5 J. Stebbins
6 Miss O'Reilly
7 Miss Carpenter
8 Miss Breslin
9 S. I. Bailey
10 E. S. King
11 Mrs. Newall
12 C. A. R. Lundin
13 E. Pringsheim
14 Miss Waterbury
15 H. F. Newall
16 W. J. Humphreys
17 W. S. Eichelberger
18 Miss Cannon
21 H. H. Turner
22 Mrs. Dugan
23 M. Updegraff
24 Mrs. Russell
25 R. S. Dugan
26 H. N. Russell
27 W. H. Pickering
28 O. Backlund
30 H. T. Stetson
31 W. W. Dinwiddie
32 H. A. Fischer
33 E. S. Manson, Jr.
35 E. C. Pickering
36 A. T. Capple
37 A. L. Rotch
38 W. A. Coit
39 B. O. Peirce
40 J. S. Plaskett
41 O. C. Wendell
42 G. C. Comstock
43 A. Belopolsky
44 Miss Allen
45 W. I. Milham
46 A. E. Douglass
47 Miss Harwood
48 F. W. Dyson
49 Mrs. Whitin
50 J. B. Coit
51 K. Schwarzschild
53 E. D. Roe, Jr.
54 Miss Whiting
55 Sir J. Larmor
56 A. Fowler
57 Mrs. Fleming
58 J. von Hepperger
59 J. R. Rydberg
60 Miss Leavitt
61 Ch. Fabry
62 Mrs. Fowler
63 C. Lundin
64 G. H. Peters
65 A. Cotton
67 J. A. Parkhurst
68 J. H. Metcalf
69 A. Wolfer
70 J. H. Poor
71 Major E. H. Hill
72 Miss Cushman

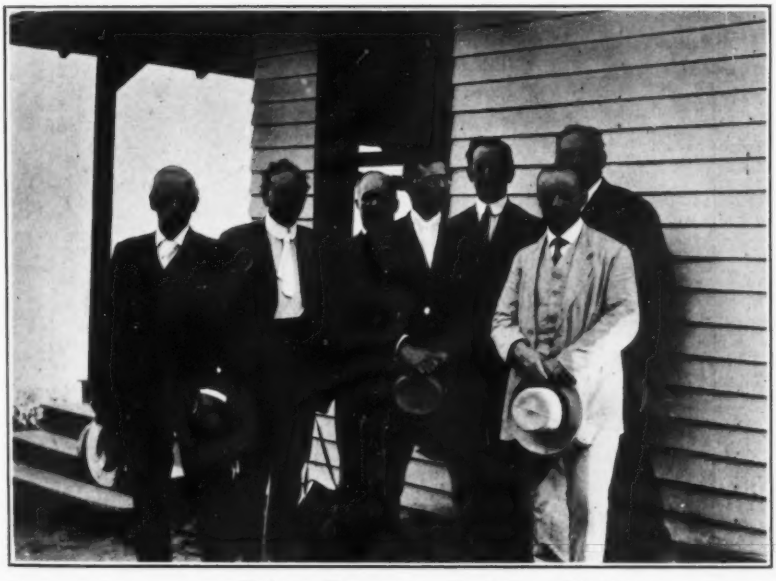


Astronomical and Astrophysical Society of America Meeting of August 19, 1910, at Harvard College Observatory.



Turner Eichelberger Backlund Comstock

AT BLUE HILL OBSERVATORY



Newall Plaskett Hartmann Frost Campbell Schwarzschild Schlesinger

COMMITTEE ON RADIAL VELOCITIES

Barnard Humphreys Turner

EMBARKING AT FLAGSTAFF

Hills (Jr.) Larmot Cortie Hills

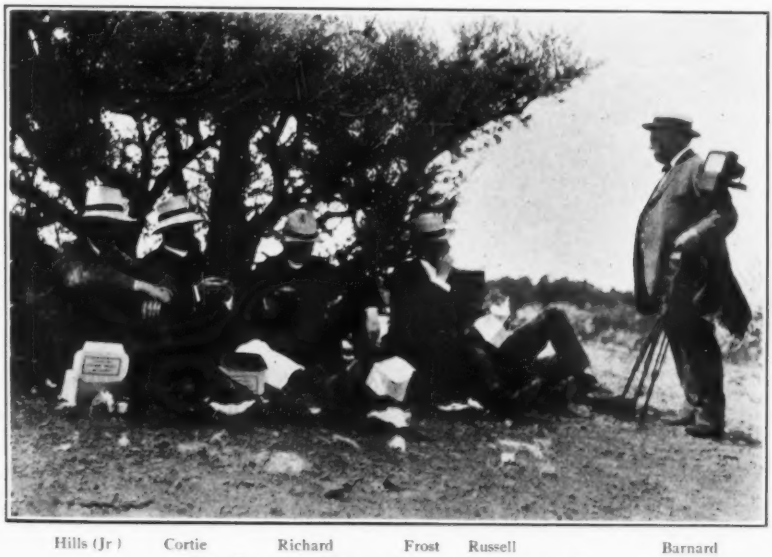
AT GRAND CANYON

Rydberg Belopolsky Fowler Wolfer Hepperger Schwarzschild Ricco

A GROUP OF EUROPEAN VISITORS, AT EL TOVAR, GRAND CANYON

Mrs. Slocum President Pickering Professor Newall

AT GRAND VIEW



Hills (Jr.) Cortie Richard Frost Russell Barnard

AT GRAND VIEW (GRAND CANYON)

tapping of a key by the student evidently gives upon a chronograph sheet information of a varied character as well as furnishing good practice. When the members, upon request of Professor Willson, tapped upon their desks at the instant of transit, the difference in personal equation was clearly shown by a succession of knocks continuing for nearly a second, while quite a ripple of amusement was caused when one belated individual struggled in about a quarter of a second after complete silence. The lantern papers, which were in some respects the most interesting of the whole meeting, were completed at about half-past five and the formal business of the eleventh meeting was over.

There were titles of forty-eight papers presented, all but three or four of which, the authors being absent, were read. As the titles and abstracts of these papers will appear in *Science*, it is unnecessary as well as impossible in the space at my disposal to go into any details. It was the general opinion that in range of subjects and in number and quality of the papers read, the present excelled all previous meetings. All sections of the country and all classes of astronomical work, with a preference possibly for astrophysical rather than astronomical problems, were represented in the papers, several of which were of exceptional value and importance. The European guests presented a number of papers which were listened to with much interest, and it is to be hoped that we may always have some papers from them even if we are not always honored by their presence. The wish expressed by many of them to be elected to membership and the unanimous and hearty way in which they were welcomed to the ranks of the Society was one of the most pleasant features of the meeting.

The reports of two committees, the Committee on Comets and the Committee on Luminous Meteors, were read. The former, which was of the most general interest, dealt with the preparations made for and the success obtained in photographing Halley's Comet. Under the auspices of this committee, an expedition in charge of Professor F. E. Ellerman, of the Solar Observatory, was sent to Hawaii, and a number of excellent

photographs secured. At the meeting on Friday afternoon three photographs were exhibited, one by Barnard at Yerkes Observatory, one by Ellerman at Hawaii and one by Joy at Beirut, Syria, which showed the rapidly increasing motion of a part of the tail and from which the acceleration under the action of the repulsive forces could be calculated.

A new committee to consider the question of co-operation in radial velocity determinations was appointed at the request of Professor Campbell, and consists of the following astronomers:

W. W. Campbell, Lick Observatory; E. B. Frost, Yerkes Observatory; F. Schlesinger, Allegheny Observatory; H. F. Newall, University Observatory, Cambridge; K. Schwarzschild, Astrophysical Observatory, Potsdam; J. S. Plaskett, Dominion Observatory, Ottawa.

This committee is quite representative, including practically all those engaged in radial velocity work. It held one meeting at Mt. Wilson, where the question was discussed in a general way, with especial reference to means of overcoming the enormous loss of light in all modern spectrographs. It is hoped that the work of this committee will have practical and useful results in this most important question.

The matter of business of the greatest interest to Canadian astronomers was the decision of the Council, acting upon the cordial invitation of Dr. King, seconded by the writer, to hold their next meeting in the summer of 1911 at the Dominion Observatory. I am sure that I am voicing the feeling of Dr. King and all the members of his staff in hoping for a large and representative meeting, not only of members of the Society but also of other astronomers who will be cordially welcomed. Although we cannot hope to show as many interesting astronomical features as at Yerkes and Harvard, nor to excel the hospitality shown at these two observatories, we shall do our best to give our visitors a pleasant and profitable time.

There is one feature of meetings of this nature which should not be overlooked, which in the opinion of many is of much greater value than the formal business of reading papers, and

that is the opportunities afforded for social intercourse. So far as I am concerned the benefits derived from meeting the eminent men in astronomy, especially afforded at this time on account of the European astronomers present, and discussing with them questions of mutual interest, far outweighs the other advantages of the meetings. A splendid opportunity for such intercourse was afforded to those who had the good fortune to attend both the meetings, at Harvard and at Mt. Wilson, in the arrangement by which the party travelled across the continent in two special cars and in the eight days occupied in the journey became almost like a family party.

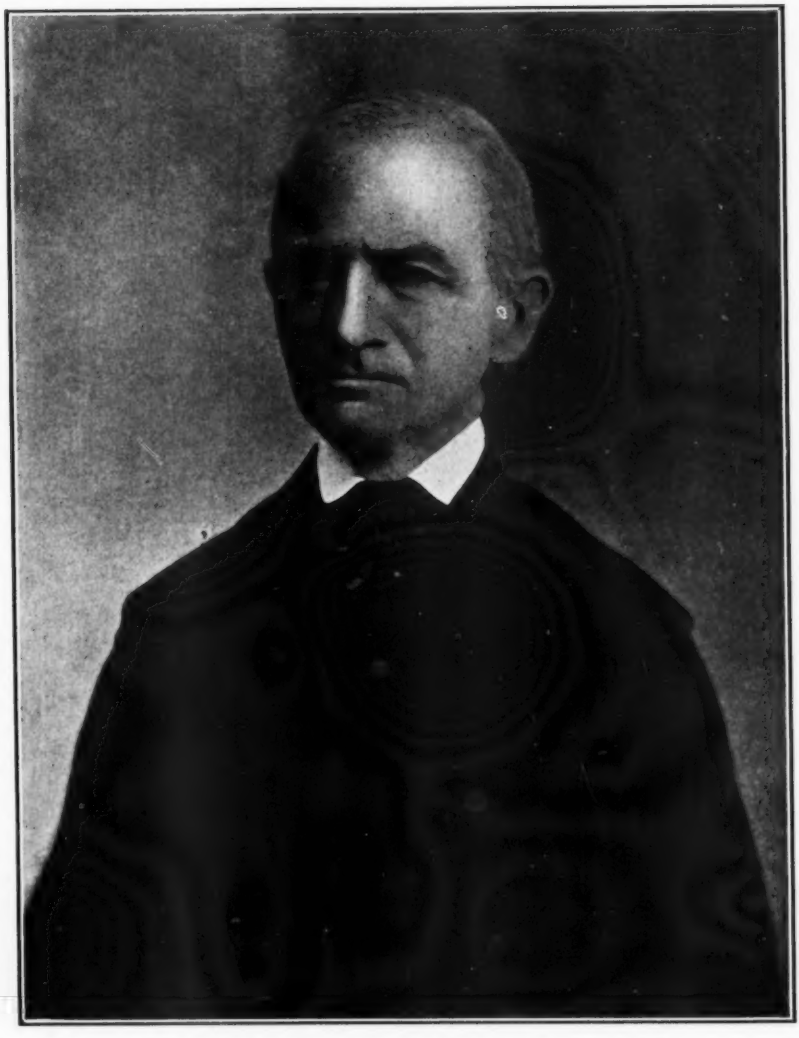
As Professor Chant is to describe the proceedings at the Solar Conference, it may be worth while to give a few impressions of the journey from Boston to Pasadena. The party left Boston on Saturday afternoon, spending Sunday at Niagara Falls and arriving in Chicago on Monday morning. We were royally entertained at Chicago by the University authorities, were driven around the parks and to the University grounds and then inspected the laboratories and other buildings of interest. The party, here increased by seven or eight members, left on Monday night by the Santa Fe Railroad for Pasadena. Although the intense heat of the next two days was not pleasant, it had its compensations in the entire abandonment of formality, to say nothing of collars and coats, which it produced. Flagstaff was reached on Wednesday night at ten o'clock, where the party was most hospitably entertained by Mr. and Mrs. Lowell at the Observatory. The magnificent collection of photographs of the planets, of Halley's Comet and other objects made here were very conveniently arranged as illuminated transparencies and were much admired.

From Flagstaff to the Grand Canyon was the next stage of the journey. The two days spent at the Canyon were too short to do justice to the wonders of this most wonderful chasm, but served to strengthen the intimacy and friendliness of the party. It must be confessed that although for two or three days out of Chicago little but astronomy and that of the most abstruse char-

acter was discussed, by the time the Canyon was reached one could listen for several minutes to a group of astronomers talking without hearing of extra-focal images, of the true place in the scale of evolution of Orion stars, of the absolute scale of stellar magnitudes, of the Zeeman effect in sunspots or any other allied subject. It was not until Pasadena was reached and the party had visited the Observatory Offices and Shops that its normal astronomical tone became restored.

The whole arrangement from first to last was most admirably planned and excellently carried out. The members of the Astronomical Society and the delegates to the Solar Union owe a deep debt of gratitude to their Executive Committees for the foresight and management which enabled the fullest advantage to be taken of the unique opportunity offered by the holding of the fourth Conference of the Solar Union at Mt. Wilson. It was certainly the most representative gathering of eminent astronomers ever held in America, and those who had the privilege of taking part in the proceedings will look back upon the period as one of the most enjoyable and profitable of their lives.

PLATE XXXIII.



JOHANN GOTTFRIED GALLE, (b. 1812—d. 1910)

(From a photograph taken by Raschkow of Breslau in 1890).

PLATE XXXIV.

FLORAL EMBLEM

Placed on the Coffin containing the remains of Peter Pilkey, 1884.

Translation of inscription :—To the worthy scholar and never-to-be-forgotten friend, Mr. Peter Pilkey.—The Family of Galle — John xi. 11.

JOHANN GOTTFRIED GALLE

By C. A. Chant

THE recent death of Johann Gottfried Galle recalls that most dramatic and inspiring episode in the history of Astronomy, — the discovery of the planet Neptune sixty-four years ago. I do not propose to discuss again the details of a story which always brings to the Britisher vain regrets for what might have been, but shall mention only a few facts relating to the busy and devoted life of the man who first knowingly observed the planet.

J. G. Galle was born on June 9, 1812, at Pabsthaus near Gräfenhainichen, about 30 miles north of Leipsic, where his father was engaged in the tar-kiln business. He was educated at Bitterfeld and Berlin, showing marked proficiency in mathematics, astronomy and Latin. For about two years (1833-5) he taught in a gymnasium, but on the completion of the new Berlin Observatory in 1835 he began work in it as assistant under J. F. Encke, the director. Here he remained for sixteen years, very busy with astronomical, meteorological and magnetic observations. Galle's first paper, which was entitled "Neue Elemente der Pallas für 1810," was published in volume 14 (1836) of the *Astronomische Nachrichten*, to which journal he was a frequent contributor until his retirement from active work at the age of eighty-five.

In 1845 he received his doctor's degree; and in 1851 he migrated to Breslau, to assume the duties of professor of astronomy at the University and director of the observatory. For nearly forty-six years, namely until 1897, he filled these positions with marked distinction. His lectures were extremely lucid, and he attracted many students to astronomy.

Galle devoted great attention to comets, spending much time and effort in completing a list of the elements of all known comets. In 1847 his first published list contained the elements

of 178 comets, discovered in the interval 371 B.C. to 1847 A.D. With the assistance of his son Dr. Andreas Galle, who is an observer in the Royal Geodetic Institute in Potsdam as well as Professor of Geodesy in the Technical High School at Charlottenburg, he published in 1894 a list, revised to date, of 414 comets. When a young man he had been a very competent observer of comets. In the short interval, December 2, 1839, to March 6, 1840, he discovered three.

In 1838 Galle discovered the crape ring of Saturn with the 9½-inch refractor at Berlin, but his note recording it was overlooked until the object was rediscovered in 1850 by Bond in the United States and Dawes in England. In 1875 he published an important paper on the determination of the solar parallax by utilising the minor planets; and from observations made on Flora (8) in 1873 he deduced the value $8''{\cdot}82 \pm 0''{\cdot}06$. This is much nearer the present accepted value than those obtained with Mars and Venus, and the method suggested is now recognised as, perhaps, the very best. Newcomb in 1867 obtained the value $8''{\cdot}848$, which was adopted and used in the almanacs for many years. Hinks' value, determined from the recent photographs of Eros, is $8''{\cdot}807 \pm 0''{\cdot}0028$.

But Galle's honorable connection with the discovery of Neptune is the most interesting feature of his astronomical career. Soon after the discovery of Uranus in 1781 the planet was found not to be following accurately the orbit calculated for it, and the idea had been continually growing that the observed irregularities were due to the attraction of another planet much beyond it. Adams in England and Le Verrier in France, two of last century's greatest mathematicians, from long, intricate and very laborious calculations, determined the position of the disturbing body. Adams communicated his results to Professor Challis and to Airy, the Astronomer Royal; but no action was taken to verify the prediction until, some months later, Le Verrier published results almost identical.

In 1845, as has been remarked, Galle obtained his Ph.D. degree. The subject of his dissertation was "Olai Rœmeri tri-

duum observationum astronomicarum a. MDCCVI. institutarum et cum tabulis comparatum" (Berlin, 1845). It comprised a reduction and critical discussion of observations made by Rœmer at his observatory near Copenhagen in the three days, October 20 to 23, 1706. This was the only portion of Rœmer's records saved from a very destructive fire at Copenhagen in 1728. Galle sent a copy of of his publication to Le Verrier, but the latter did not acknowledge it until he wrote regarding the predicted new planet. Le Verrier's letter is given in full, for the first time, by Dr. T. J. J. See in the October number of *Popular Astronomy* and is as follows:

U. J. LeVerrier to J. G. Galle

Paris, le 18 Septembre 1846.

Monsieur,

J 'ai lu avec beaucoup d' interêt et d' attention la reduction des Observations de Rœmer, dont Vous avez bien voulu m'envoyer un exemplaire. La parfaite lucidité de Vos explications, la complète rigueur des résultats que Vous nous donnez, sont au niveau de ce que nous devions attendre d'un aussi habile astronome. Plus tard, Monsieur, je Vous demanderai la permission de revenir sur plusieurs points, qui m' ont interessé, et en particulier sur les Observations de Mercure qui y sont renfermées. Aujourd'hui je voudrai obtenir de l' infatigable observateur qui 'il voulais bien consacrer quelques instants à l' examen d' une region du Ciel, où il peut rester une Planète à découvrir. C'est la theorie d'Uranus qui m' a conduit à ce résultat. Il va paraitre un extrait de mes recherches dans les *Astronomische Nachrichten*. J'aurai donc pu, Monsieur, me dispenser de Vous en écrire, si je n'avais eu à remplir le devoir de Vous remercier pour l'intéressant ouvrage que Vous m'avez addressé.

Vous verrez, Monsieur, que je démontre qu'on ne peut satisfaire aux observations d'Uranus qu'en introduisant l'action d'une nouvelle Planète, jusqu' ici inconnue : et ce qui est remarquable, il n'y a dans l'écliptique qu' une Seule position qui puisse être attribuée à cette Planète perturbatrice. Voici les elements de l' orbite que j' assigne à bet astre :

Demi-grand axe de l'orbite - - - -	36·154
Durée de la révolution sidérale - - -	217·387 ans.
Excentricité - - - - - -	0·10761
Longitude du Perihelie - - - - -	284° 45′

Longitude moyenne 1r Janvier, 1847 - -	318° 47′
Masse - - - - - - - - -	1/9300
Longitude Heliocentrique vraie au 1r Janvier, 1847	326° 32′
Distance au Soleil - - - - - - -	33 06

La position actuelle de cet astre montre que nous sommes actuellement, et que nous serons encore, pendant plusieurs mois, dans les conditions favorables pour le découvrir.

D'ailleurs, la grandeur de sa masse permet de conclure que la grandeur de son diamètre apparent est de plus de 3″ sexagésimales. Ce diamètre est tout-à-fait, de nature à être distingué, dans les bonnes lunettes, du diamètre fictive que diverses aberrations donnent aux étoiles.

Recevez, Monsieur, l'assurance de la haute considération de Votre dévoué serviteur,

U. J. LeVerrier.

Veuillez faire agréer à Mr. Encke bien que je n'aye pas l'honneur d' être connu de lui, l' hommage de mon profond respect.

A Monsieur J. G. Galle,
Astronome à l' Observatoire
Royal de Berlin.
à Berlin.*

*Translation.—

Paris, 18th September 1846.

Sir,—

I have read with much interest and attention the reduction of Rœmer's Observations, of which you were good enough to send me a copy. The perfect clearness of you explanations, the complete rigor of the results which you give are on the level of what we should expect from so skilful an astronomer. Later, sir, I shall ask permission to return to several points which interest me, particularly to the Observations of Mercury which are included.

To-day I should like to ask the indefatigable observer to be good enough to devote a few moments to the examination of a region of the heavens where, perhaps, there is a planet awaiting discovery. It was the theory of Uranus which led me to this conclusion. There will appear an extract from my investigations in the *Astronomische Nachrichten*. In view of this, sir, it was scarcely necessary to write to you in this regard, were it not that already there had devolved on me the pleasing duty of thanking you for the interesting work which you had kindly sent me.

You will see, sir, that I show that the observations on Uranus can be satisfied only by introducing the action of a new planet hitherto unknown; and, remarkable as it may seem, there is only one position in the ecliptic to which can be assigned this perturbing body.

The letter reached Galle on September 23, and that very evening an object corresponding to the one described was discovered with the 9½-inch refractor. Further observations on the two following evenings established beyond doubt that the object was a new planet. Meanwhile Challis was making his search, but he had delayed too long, and the honor of the discovery rested elsewhere.

Upon relinquishing his work at Breslau Galle took up his residence at Potsdam. On his ninetieth birthday, on June 9, 1902, deputations from various scientific societies presented him with congratulatory addresses, and the vigorous old man remained standing while listening to all the addresses and replying to each in turn. All the letters which he received upon this and later birthdays and at New Years he answered in his own handwrit-

I give below the elements of the orbit which I have constructed for this planet :—

Semi-major axis of the orbit	36·154
Sidereal period of revolution	217·387 years
Eccentricity	0·10761
Longitude of perihelion	284° 45′
Mean longitude, 1st Jan., 1847	318° 47′
Mass	1/9300
True heliocentric longitude 1st January 1847	326° 32′
Distance from the sun	33·06

From the position assigned to this planet it will be seen that the conditions for its discovery are, and will continue for several months, distinctly favorable.

Moreover, the magnitude of its mass allows us to conclude that its apparent diameter is more than 3 seconds of arc. This diameter is surely large enough to be distinguished, in a good telescope, from the spurious diameters given to stars through instrumental imperfections.

Accept, sir, the assurance of the high consideration of your obedient servant,

U. J. LeVerrier.

Please convey to Mr. Encke, although I have not the honor of knowing him, the tribute of my profound regard.

To Mr. J. G. Galle,
Astronomer at the Royal Observatory,
Berlin.

ing, and not until his ninety-eighth birthday, on June 9, 1910, did he allow his son to write his replies for him. His health at that time was moderately good, but about July 1 he became ill and on the night of July 10 he died.

The good name of the University of Breslau has for years attracted numbers of Canadian students. Among those living in Toronto are Dr. A. P. Coleman, professor of Geology in the University of Toronto, and Dr. A. J. Bell, professor of Latin in Victoria College, both of whom obtained the doctor's degree there. Dr. Coleman left Breslau in 1881. Though not a special student in astronomy he occasionally attended Galle's lectures, and he remembers the high esteem in which the astronomer, even then an old man, was held. Dr. Bell was at Breslau from 1886 to 1889. He recalls that the astronomer was of medium height and wore a decidedly impassive and somewhat ascetic appearance, seldom being seen to smile. In his work he was very quiet and modest, never being known to aim at a superficial popularity. Dr. Bell frequently attended the preaching of the Moravians in Breslau, and he recalls seeing Galle often there.

At Victoria College there is preserved an interesting relic which reveals the kindly nature of the deceased astronomer. In the year 1882 Peter Thomas Pilkey graduated with the gold medal in mathematics at Victoria University, (then in Cobourg), and soon after went to Breslau to continue his studies. He specialised in mathematics and astronomy and so took work with Galle. About a year and a half later his health failed, and on January 21, 1884, he passed away, having just completed his twenty-fourth year. The body was embalmed, shipped to Ontario and interred in the family plot at Uxbridge. During his last illness, we are informed, he was cared for as by brothers. When the remains were taken to the station they were accompanied by an immense cortege of friends formed in educational and religious circles. When the case was opened, upon arrival in Canada, the coffin was found to be covered with loving floral emblems. Among these was a tribute from the family of Galle. It consists of a

wreath of white roses surmounted by a frond of palm, to which is attached a white ribbon bearing the inscription : " Dem werthen Schüler und unvergeszlichen Freunde, Herrn Peter Pilkey.— Die Familie Galle, Ev. Johann 11, v. 11.

Galle was a skilful and accomplished astronomer distinguished for his fidelity and carefulness, but the single incident just described showed that he possessed, as well, a generous and loving spirit.*

* For a fuller account of Galle's work reference may be made to an article by F. A. Bellamy, in *Knowledge*, for August and September, 1910.

MEETINGS OF THE SOCIETY

At Toronto

October 11.—At the request of the President, who was suffering from hoarseness, Mr. W. B. Musson took the chair.

The secretary, Mr. J. R. Collins, stated that a communication had been received by the Council of the Society from the Saskatchewan Astronomical Society, asking that that Society be incorporated into the Royal Astronomical Society of Canada, to be known as the Regina Centre. The Council, by resolution, favored such action, but the new Centre could not be formally instituted until the members of the Saskatchewan Society were elected members of the R.A.S.C.

The following were then nominated for membership :—

Mr. N. MacMurchy, Mr. A. J. Pyke, Mr. J. E. Doerr, Mr. J. A. Covington, Mr. T. B. Patton, Mrs. T. B. Patton, Mr. R. Smillie, Mr. J. F. Bryant, Mrs. J. F. Bryant, Mr. J. Duff, Mr. W. M. Logan, Mr. H. Lang, Mr. J. R. C. Honeyman, Mr. H. S. McClung, Mr. Geo. Simpson, Miss H. E. Chisholm, Miss M. E. Pierce, Mr. C. B. Keenleyside, Miss K. B. Coleman, Miss J. Hamilton, Mrs. E. C. Lang, Miss E. D. Cathro, Mr. D. Brown, Mr. Wm. Trant, Mr. H. F. Black, Mr. J. T. Brown, Mr. A. H. de Tremaudan, all of Regina.

It was moved by Prof. A. T. DeLury, seconded by Prof. C. A. Chant, that the by-law requiring two weeks to elapse between nomination and election be suspended, and that the secretary be instructed to cast a ballot for the election of those whose names appear above. This was carried unanimously. The chairman then declared the above candidates to be members of the Royal

Astronomical Society of Canada, and the establishment of the Regina Centre was thus completed.

Mr. J. R. Collins referred to some observations by Professor Lowell on Saturn's Ring and on the markings of Jupiter. Certain equatorial formations on Jupiter's surface had been frequently observed during the summer.

Mr. R. M. Wallace gave an interesting account of his work on a reflecting telescope. He has made several mirrors, and has had considerable success in using a flat mirror to reflect the light back through an opening at the centre of the objective instead of a concave one as in the Gregorian type.

The programme consisted of reports of summer observations. Prof. C. A. Chant gave a short account of astronomical incidents on his route to attend the Solar Conference at Mt. Wilson in California. At Regina he lectured before the Society there, and reported very favorably on the energy and enthusiasm displayed there. At Edmonton Halley's Comet was not entirely forgotten. Many there did not see it and some were inclined to consider it rather a myth. The one in January, 1910*a*, was seen to good advantage, and was considered much finer than Halley's. Edmonton is in north latitude 53° 33′, and at the time of the comet's visit in May the twilight was too long for the object to be seen well. At the Lick Observatory many changes in the staff had been made recently, and a new photographic house has been erected.

Mr. L. Gilchrist gave a brief account of work bein carried on at the University of Chicago, where he had spent the summer. He reported progress made by Professor Michelson in ruling gratings.

October 25.—The following were elected members of the Society:—

Miss Ella Goodall, Toronto.

Prof. F. P. Brackett, Pomona College, Claremont, Cal.

Mr. H. W. Barker, Toronto.

Mr. J. R. Collins reported observations on the Perseid

Meteors on August 9 and 10. Mr. R. M. Wallace had observed an increase in the sun-spots seen recently.

Prof. C. A. Chant gave an address on "Notes on the Meeting of the International Solar Union at Mt. Wilson, California." First the lecturer gave a historical account of the establishment of the Solar Union and an outline of the objects in view, *viz.* co-operation in solar research—for example in the standardisation of wave-lengths, and in experimental and theoretical work on solar radiation and the connection between solar and terrestrial phenomena. The proceedings of the sessions of the Conference were described and the results of researches which were presented at the meeting were outlined. Special reference was made to measurement of wave-lengths, work on sun-spots (including their spectra), star-streaming and the spectroheliograph. The social features of the meeting were also mentioned, and an interesting account given of informal talks with men working on the great scientific problems of the day.

An account was also given of the great Mt. Wilson Solar Observatory with its wonderful equipment. The lecturer pointed out the advantages for astronomical research possessed by it, and the conditions under which the work is carried on. A review was also made of the success which has attended the work of Director Hale and his staff.

L. G.

AT OTTAWA

March 24, 8 p.m., in Y. M. C. A. Hall.—Mr. J. S. Plaskett lectured on the "Determination of the Constitution and the Radial Motions of the Stars," this being the second of his course on astrophysics. He showed how the spectroscope was used to analyze the light coming from distant luminous bodies, and exhibited slides of spectra of stars and comets, including Halley's.

April 7, 3 p.m., in the Observatory.—The minutes of this meeting appear on page 217 but the date there given is incorrect.

April 21, 8 p.m., in Y. M. C. A. Hall.—Mr. J. S. Plaskett gave a lecture on "Stellar Evolution and Theories of World

Building." This outlined the modern conception in regard to the development of stars from nebulæ, and their process of growth and decay, together with a summary of the theories held in regard to the formation of and evolution of our system, explaining how it has reached its present stage of development.

May 3, 3 p.m., at the Observatory.—At this meeting two papers were presented. One was by Dr. R. E. De Lury on "The Grating of the Solar Spectrograph"; the other was by Mr. J. S. Plaskett on "The Effect of Slit Width in a Spectrograph." Both papers were of a technical nature, and of great interest and value to those working in astrophysics. Mr. Plaskett's paper appears at page 333 of this issue.

May 26, 8 p.m., in Y. M. C. A. Hall.—This was the tenth and final meeting of the session and was a popular lecture on "Comets" by Dr. O. Klotz, who responded to the common craving for knowledge of these bodies by outlining what we know and also what we have yet to learn about them.

October 13.—The fall term of 1910 was opened by a meeting at the Observatory on this date, when Dr. Klotz lectured on "Terrestrial Magnetism." By the aid of several simple experiments with a magnetized needle Dr. Klotz explained the principal facts of terrestrial magnetism, and then described the instruments used to measure the earth's magnetic forces. In conclusion he spoke of the phases of the subject now claiming the attention of investigators, such as the cause of daily variation, the cause of magnetic storms and their connection with sun-spots and the time of transmission of electric storms.

Mr. C. H. Taggart, 25 Patterson Ave., Ottawa, was elected a member at this meeting.

October 27.—The second meeting of the fall term was held at the Y.M.C.A. hall, on this evening, when Dr. C. A. Chant, Professor of Astronomy at the University of Toronto, gave a popular lecture on "The Universe of Stars." The subject was presented in a very pleasing manner and was thoroughly enjoyed

by those present, a strong feature being the series of fine views of interesting things to be seen in the heavens.

C. E.

At Hamilton

October 14.—The first meeting for the session was held this evening, the local president, Mr. G. P. Jenkins, being in the chair.

Professor A. T. DeLury, the President of the Society, gave a lecture on "The Astronomy of To-Day." In order properly to understand the astronomy of to-day, a comprehensive survey of the past must be made and the outstanding advances examined.

Early man, when he first turned his attention to things beyond the merely animal, sought an explanation of the daily revolution of the heavens, and the obvious one of making the earth the centre of all things was adopted.

Further and more acute observations led to the discovery of differences which suggested the cycles and epicycles of the Ptolemaic system. A knowledge of the great distances of the celestial objects gave a view of their immense size and the relative insignificance of our earth, and together with the great velocities demanded led to the discarding of the Ptolemaic for the Copernican system.

Newton and a knowledge of law of gravitation led on to the understanding of *why* the heavenly bodies moved as they did.

The question arose, Does this law hold good beyond the confines of our system? Before this was answered other problems were met and answered. The theory of evolution propounded by Laplace demanded that the sun and the planets be all composed of similar materials. For a long time it seemed that no knowledge of this were possible, but the work of Fraunhofer and Kirchhoff showed how to read the truth in the lines of the spectrum. Then followed the answer of the other problem. Doppler's principle gave a knowledge of motion in the line of sight, and the study of binary systems showed that Newton's law of inverse squares held beyond the boundaries of our system.

Reference was made to the study of sun-spots. By the aid of the light of various elements, photographs of a spot at various depths in the sun's atmosphere have been made, and copies of these were thrown upon the screen.

A hint of the possible connection between economics and astronomy was given, in that the periodicity of sun-spot activity seemed to be connected with the productivity of the earth.

At the close, a hearty vote of thanks was tendered the lecturer. T. H. W.

At Regina, Saskatchewan

organisation of the regina centre

I shall give a brief outline of our work at Regina, and can assure the readers of the JOURNAL that we have already had many enjoyable evenings of study and instruction under the guidance principally of Mr. Wm. Trant and Mr. A. J. Pyke.

On the evening of February 18th of this year a meeting was held of those interested in the formation of an Astronomical Society. Those present were so favorable to this proposition that, without further delay a committee was appointed to draft a constitution and report at a meeting one week later. On this date, February 25th, the Saskatchewan Astronomical Society was formally organised, the constitution read, discussed and adopted clause by clause and the following officers elected :

Hon. President—Mr. Wm. Trant.
Hon. Vice-President—Mr. P. McAra, Jr.
President—Mr. N. MacMurchy.
First Vice-President—Mr. H. Lang.
Second Vice-President—Mrs. J. F. Bryant.
Treasurer—Mr. J. F. Bryant.
Secretary—Mr. H. S. McClung.
Executive Committee—Mr. C. B. Keenleyside, Mr. J. E. Doerr, Miss E. D. Cathro.

Our first regular meeting was held on March 4, at which a paper entitled "Going to the Heavens with a Yardstick," was

given by Mr. Trant, who graphically illustrated on the blackboard how celestial measurements are made. This paper was ably supplemented by Mr. Pyke, whose subject on March 18 was "How to Find a Star," and on April 1 "Fixed Stars."

At the latter meeting the Society was gratefully pleased to learn that the Collegiate Institute Board had granted to it the use of a class room for its meetings.

On April 15 Mr. J. Duff dealt with the "Solar System." This and our former meetings had been so enjoyable that on April 30 the Society entertained its friends and the public at an open meeting. Mr. Pyke on this occasion lectured on "The Solar System and Its Comets," a most pleasing feature being the illustration of his subject by a series of slides kindly loaned for the occasion by Dr. Chant, of the University of Toronto. The members of the Society and the people of Regina were further indebted to Dr. Chant for a lecture by him on July 26. The subject was "The Universe of Stars," being an introduction to popular astronomy, and was illustrated by an excellent series of lantern views.

In May it was decided to apply for affiliation with the Royal Astronomical Society of Canada. The Council of the Society at once reported favorably regarding the application but stated that the formal institution of the Regina Centre could not be made until the members composing it were elected members of the Society. This election took place at the Toronto meeting on October 11,* and we now boast of being the Regina Centre of the Royal Astronomical Society of Canada.

Our study this winter will be Moulton's "Introduction to Astronomy," which we are taking up chapter by chapter at our regular meetings, and such practical work as we can undertake.

In the matter of practical observation we are singularly fortunate. The means whereby we can accomplish this work were provided by a handsome gift from one of our members, the Honorable Mr. Justice J. T. Brown. Observing our thirst after celestial knowledge, he presented the baby society with a bottle

*See page 386, where appears the list of members.—Ed.

which supplies an unfailing draught. This is a Brashear's Telescope, 4½-inch aperture, with equatorial mounting and tripod base. The Society is, however, planning to construct a dome and permanent rigid base to better facilitate the operation of this splendid instrument.

We of the West believe that our utmost endeavors will not exceed the material progress of this portion of our Dominion, and so we are striving after all the good things that are obtainable and among them is a liberal education. With the aid of our institutions of learning and the support of our liberal public men this is surely within our grasp for the taking.

REGINA, SASK. H. S. MCCLUNG,
October 17, 1910. *Secretary.*

NOTES FROM THE DOMINION OBSERVATORY

Astrophysics

Spectroscopic Binaries under Observation at the Dominion Observatory.

About a year ago there was published in these Notes a list of the spectroscopic binaries under investigation at Ottawa.* As considerable changes have been made in the observing programme since that date, it has seemed desirable to publish a revised list in order that unnecessary duplication of work may be avoided.

Since the publication of the previous list, orbits of the following binaries have been completed.

ϕ Persei
τ Tauri
93 Leonis
η Boötis
α Draconis
ϵ Ursæ Minoris.

In addition work on the three binaries,

ν Orionis
7 Camelop
ω Ursæ Majoris,

is nearing completion.

Omitting these and one or two others from the previous programme, and adding several, kindly communicated in advance of

*This Journal Vol. III., p. 465. (November-December, 1909).

publication by Professor Frost, as well as some already published, we have the following list of stars already under observation or proposed for observation in the near future,

ξ Tauri	d Bootis
b Persei	β Coronæ
86ρ Tauri	B.D, $-4°$ 4275
θ' Tauri	γ Ophiuchi
θ^2 Orionis	68 Ophiuchi
γ Geminorum	72 Ophiuchi
ϕ Geminorum	ϵ Cygni
γ Corvi	γ Aquarii
23 Comæ	α Pegasi

J. S. P.

Correction

In the article on the "Orbit of ϕ Persei," published in the May–June number of this Journal, a mistake was made in the computation of the probable error of a plate, and in the probable errors of each of the elements, by the omission of the factor ·6745. The correct value of these are :—

Probable error of a plate of weight unity	$\pm$ 4·14
" " of γ " " "	$\pm$ ·50
" " " K " " "	$\pm$ 1·03
" " " e " " "	$\pm$ ·0287
" " " ω " " "	$\pm$ 4·18
" " " T " " "	$\pm$ 1·32
" " " K' " " "	$\pm$ ·89
" " " T' " " "	$\pm$ 1·40

J. B. C.

MAGNETIC OBSERVATIONS

During the past season some 48 stations have been occupied along the Canadian Pacific Railway between Chapleau and Moose Jaw, covering about 22° of longitude. Declination, Inclination and Intensity were observed at each station, and at many stations the diurnal variation also.

We hope to be able to give the results in the next issue.

In Western Ontario it is expected that some 45 stations will have been occupied when the season closes.

The base station, Agincourt, is always occupied before and after the season's work.

THE SEISMOGRAPH—BOSCH PHOTOGRAPHIC, 200 GRAMMES

The following earthquakes have been recorded since the last notes were sent :—

1910		N–S Component	E–W Component
August 11		h m s	h m s
	1st P. T.	16 36 20 (?)	16 36 24 (?) G.M.T.
	2nd P. T.	16 41 34	16 41 31
	P. P.	16 42 10	16 42 28
	Max.	16 47	16 46 40
	End	17 48	17 48
	Distance 3400 km.		
August 21			
	1st P. T.	5 56 22	5 36 36
	2nd P. T.	6 01 56	6 01 51
	P. P.	6 05	6 05
	Max.	6 12	6 07
	End	7 15	7 18
	Distance 3600 km.		
September 1			
	Waves	1 38	1 37
	Long Waves	1 50	1 50
	End	2 10	2 12
September 6			
	1st P. T.	20 04 27	20 04 19 (?)
	2nd P. T.	20 14 37	20 14 38
	P. P. (?)	20 28·5	. . .
	Max.	20 46	20 46
	End	21 35	21 15
	Distance 9000 km.		
September 7			
	1st P. T.	7 31 49	7 31 49
	2nd P. T.	7 38 48	7 38 44
	P. P.	7 45·5	7 45·6
	Max.	8 20	8 20
	End	9 32	9 26
	Distance 5300 km.		

		N–S Component h m s	E–W Component h m s	
September 7				
	Waves	10 47	10 47	G.M.T.
	Max.	11 00	11 00	
	End	12 08	11 57	
September 9				
	1st P. T.	1 23 42	1 23 46	
	2nd P. T.	1 32 00	1 32 00	
	P. P.	. . .	1 42	
	Max.	. . .	1 50	
	End	. . .	3 37	
September 9				
	Waves	. . .	9 33	
	Long Waves	. . .	10 07	
	End	. . .	10 35	
September 16				
	Waves	19 25 36	19 25 36	
	Max.	19 29	19 29	
	End	19 43	19 44	
September 22				
	1st P. T. (?)	12 50 53	12 50 51	
	2nd P. T. (?)	12 54 30	12 53 51	
	P. P.	12 58	13 02	
	End	13 27	13 20	
September 24				
	1st P. T.	3 39 20	3 39 20	
	2nd P. T.	3 44 52	3 44 52	
	P. P.	3 50·5	3 50·5	
	Max.	3 58	. . .	
	End	5 05	4 56	

Distance 3750 km.

September 24				
	1st P. T.	4 20 47	4 20 47	
	Waves	. . .	4 23	
	Max.	4 23·7	4 24·7	
	End merged in preceding.			

		N–S Compouent	E–W Component	
		h m s	h m s	
September 24				
	1st P. T. (?)	18 47 17	. . .	G.M.T.
	2nd P. T.	18 53 00	18 52 51	
	P. P.	19 02	19 00	
	Max.	19 03·5	19 01·5	
	End	19 46	19 26	
October 4				
	1st P. T.	23 10 52	. . .	
	2nd P. T.	23 19 34	23 19 36	
	P. P.	23 31·5	23 31·3	
	End	24 18	24 00	
Distance 7200 km.				
October 16				
	Waves	2 31	2 31	
	End	2 45	2 44	
October 18				
	Waves	3 30	3 39	
	Long Waves	3 42	3 49	
	End	4 05	3 55	

For the more detailed study of seismograms, an electric recording anemograph of Fuess (Steglitz-Berlin) No. 1792 has recently been installed. It registers automatically in ink the direction, velocity and pressure of the wind. The direction is confined to N, N E, E, S E, S, S W, W, N W, while for pressure there are 12 electric contacts corresponding to pressures from 0 to 7·52 pounds to the square foot or an indicated velocity of about 54 miles per hour. The anemometer cups are larger than usual, being 20½ cm. in diameter, and the arms 80 cm. from centre to centre of cups.

We have now the thermogram (Callendar), micro-barogram (Shaw-Dines), anemogram (Fuess) and seismogram (Bosch) for inter-comparison, especially for interpretation of the last when the record thereon is not due to earthquakes.

It may be, perhaps, of interest to note that the presence of a party of some forty visitors at the Observatory in the room above the seismograph room, which is in the basement, caused

a pressure along the partition wall on to the earth, thereby distinctly tilting the pier and deflecting the pendulum. The tilting was equivalent to one inch in 33 miles. The time of arrival and departure of the party in this particular room could be quite well read in the seismogram.

OTTO KLOTZ.

DOMINION OBSERVATORY,
OTTAWA, CANADA,
Oct. 19, 1910.

NOTES FROM THE METEOROLOGICAL SERVICE

Summary Report of the Weather in Canada

August, 1910

Temperature — The temperature was everywhere below the average from the Pacfiic Coast to Lake Superior district, locally below in the other portions of Ontario east of Lake Superior and also in Western Quebec ; elsewhere it was abcve the average. The most marked negative departure occurred in Southern Saskatchewan, amounting to 8 degrees, and the greatest positive departures in the Gulf of St. Lawrence, ranging from 3 to 6 degrees.

Precipitation — In British Columbia the rainfall was very deficient over Vancouver Island and the Lower Mainland, but rather more than usual at certain interior points. Alberta and Southern Saskatchewan recorded a rainfall of from 2 to 4 inches, which is from one-third to a half in excess of the average amount. In North Saskatchewan and Manitoba the rainfall did not reach the usual quantity. In Ontario and over Western Quebec it was nearly everywhere heavy and well above the average, whereas in Eastern Quebec and over the Maritime Provinces it was generally moderate and much below the average. The total fall at Charlottetown was less than an inch, being 2·70 inches below average. Halifax was 1·80 inches below the average. The greatest total fall for the month reported from any one station was 6·2 inches at Wiarton, Ont., and the smallest 0·25 inches at Cowichan, B.C.

Temperatures for August and September

Station	August		September	
	Highest	Lowest	Highest	Lowest
Yukon				
Dawson	74	25	70	14
British Columbia				
Atlin	72·0	28·0	66	26
Agassiz	82	41	84	40
Barkerville	74	24	68	20
Kamloops	92	35	86	30
New Westminster	85	37	80	40
Prince Rupert	72	43	72	38
Vancouver	82	39		
Victoria	80	43	78	42
Western Provinces				
Battleford	90	32	84	32
Broadview				
Calgary	84	30	80	18
Carman	80	28	80	28
Edmonton	83	33	82	26
Medicine Hat	87	38	83	33
Minnedosa	86	30	86	22
Moose Jaw	93	31	84	22
Oak Bank	87	35	76	28
Portage la Prairie	92	33	80	30
Prince Albert	84	32	82	20
Qu'Appelle	86	35	80	24
Regina	91	32	82	25
Swift Current	88	31	82	28
Winnipeg	93	30	78	28
Ontario				
Agincourt	84	48	81	35
Aurora	85	41	79	27
Bancroft	84	34	76	25
Barrie				
Beatrice	98	39	75	25
Birnam	84	45	78	39
Bloomfield	87	48	75	36
Brantford	87	44	82	33
Bruce Mines	80	41	75	31
Chatham	93	41	86	39
Clinton	86	42	78	35
Cottam	93	40	87	34
East Toronto	82	46	79	40
Gravenhurst	84	40	77	29
Guelph	85	43	78	34
Haliburton	84	37	78	25
Hamilton	85	51	79	42
Huntsville				
Kenora	89	38		
Kinmount	83	36	75	23
Kingston	83	49	75	36
Lakefield			78	35
London	91	45	85	30
Lucknow	87	39	79	33
Madoc	82	41	75	32
Meaford	83	49	79	37
Midland	88	60	82	40
North Gower	90	40	80	30
Otoanbee	85	40	73	36
Ottawa				
Owen Sound	86	40	80	33
Paris	87	45		
Parry Sound	84	45	77	31
Peterboro'	85	40	75	32
Point Clark	85	50	75	32
Port Arthur	83	39	75	28
Port Burwell	83	48	76	37
Port Dover	86	49	81	39
Port Hope				
Port Stanley	82	46	77	37
Ronville	79	42	74	27
Sarnia	79	38	79	38
Southampton	84	46	80	37
Stonecliffe	81	40	75	28
Stony Creek	88	48	83	40
Stratford	85	43		
Toronto	85	48	81	39
Uxbridge	84	43	79	29
Wallaceburg	91	44	83	37
Welland	85	47	80	43
White River	80	28	72	22
Quebec				
Brome	81	33	71	30
Father Point	81	37	68	28
Montreal	83	50	73	39
Quebec	82	40	72	37
Sherbrooke	82	42	74	31
Maritime Provinces				
Charlottetown	82	43	70	32
Chatham	85	40	76	33
Dalhousie	85	40	73	35
Fredericton	84	38	75	33
Halifax	81	39	77	36
Moncton	81	34	75	30
St. John	78	48	73	44
St. Stephen	82	36	75	31
Summerside				
Sussex	80	33	73	31
Sydney	82	44	75	35
Yarmouth	75	39	73	36

SEPTEMBER, 1910

Temperature — The mean temperature of this month was below the average over nearly the whole of the Dominion and in the few districts where a positive departure occurred, it nowhere exceeded 1°. The deficiency was for the most part less than 2° except in the Ottawa Valley and Western Quebec where in some localities the mean was as much as 5° and 6° below average.

Precipitation — The rainfall was below the usual amount throughout British Columbia, also in Western Provinces, except locally in the latter, the localities departing from the rule being a few points in Alberta, Northwestern Saskatchewan and Eastern Manitoba. In Ontario the rainfall was locally above the average in a few districts, otherwise everywhere below. In Quebec it was either average or below, and in the Maritime Provinces below in all localities, except in Cape Breton, where in some parts a small positive departure was recorded. The largest rainfall reported for the month was 3·97 inches at Toronto and the smallest 0·40 inches at Kamloops.

R. F. S.

MAGNETIC OBSERVATIONS

JUNE — SEPTEMBER

During the month of June light disturbances were recorded on the 7th to 13th, on the 20th to 23rd with a sharp increase of force from 13 to 16 o'clock on the 20th, and on the 29th.

July was a very quiet month with light disturbances occurring only on the 4th and 5th and on the 23rd and 24th.

August was a very unquiet month with light disturbances on the 1st, 2nd and 14th, and moderate disturbances on the 9th and 10th, and continuously from the 18th to 23rd and from the 28th to 31st. On the 10th and 22nd the limit of the photographic trace was exceeded. During the 9th and 10th auroræ were recorded generally from the Rocky Mountains to the Gulf of St. Lawrence, and during the disturbance of the 22nd, although

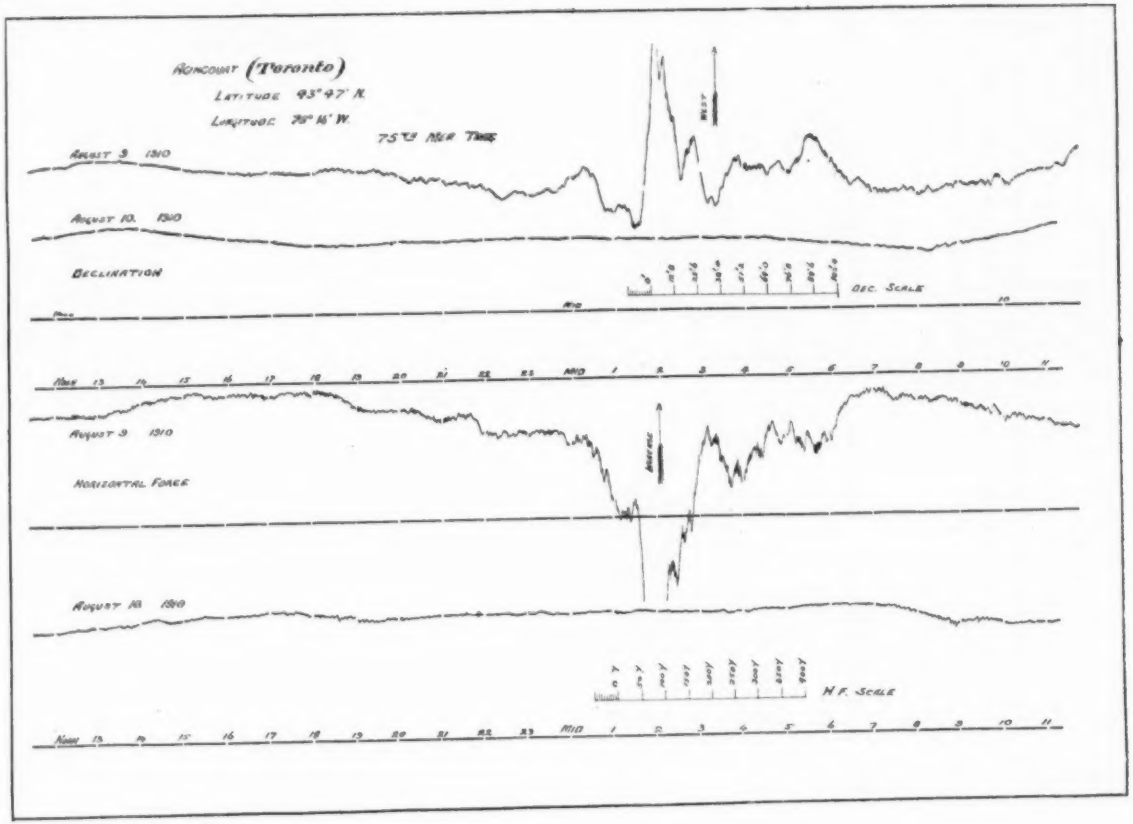
the weather throughout Canada was generally clouded, a few widely separated places records auroræ of the 1st class.

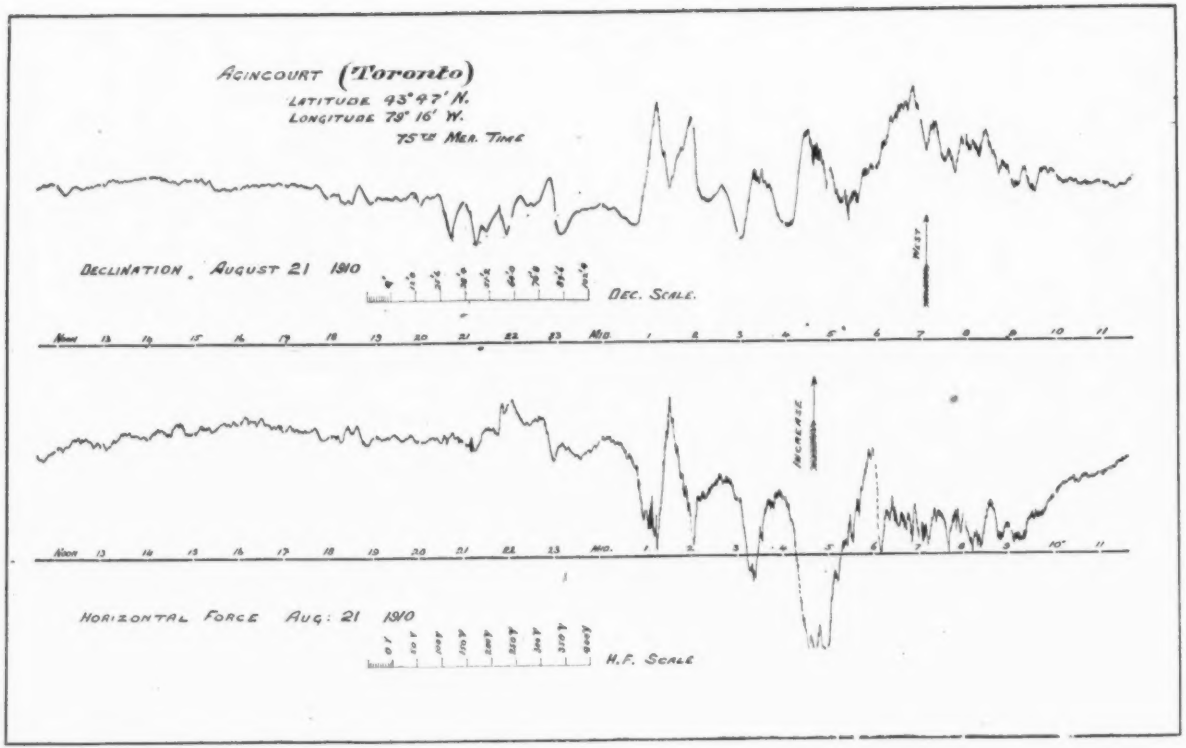
During the first half of September the magnets were steady, except for a light disturbance on the 6th, whilst from the 20th to 29th continuous wavy movements were recorded, but none of any magnitude.

Month	Mean of Month	Max.	Date	Min.	Date	Monthly Range	Amplitudes--Mean Daily	
							From hourly readings	From Means of Extremes
Declination								
	° ′	° ′		° ′		° ′	° ′	° ′
June	6 03·5	6 21·6	20	5 29·7	21	0 51·9	0 11·7	0 17·4
July	6 03·7	6 17·1	10	5 38·6	4	0 38·5	12·2	17·1
Aug.	6 04·7	7 22·6	10	5 33·5	10	1 49·1	12·6	26·3
Sept.	6 05·1	6 36·1	29	5 32·7	24	1 03·4	10·1	20·8
Bifilar								
	C.G.S.units							
June	·16284	·16610	20	·16215	19	·00395	·00042	·00072
July	·16279	·16341	4	·16185	5	·00156	·00039	·00061
Aug.	·16263	·16351	22	*·15881	10, 22	·00470	·00048	·00100
Sept.	·16261	·16325	6	·16109	29	·00216	·00046	·00072

* Minimum went below this limit of record.

Month	Mean
Inclination	
	° ′
June	74 37·2
July	74 37·8
August	74 38·5
September	74 38·8


Agincourt (Toronto)
Latitude 43° 47' N.
Longitude 79° 16' W.
75° 13' West Time
August 9 1910
August 10. 1910
Declination
West
Dec. Scale
August 9 1910
Horizontal Force
August 10 1910
H.F. Scale


AGINCOURT (Toronto)
LATITUDE 43° 47' N.
LONGITUDE 79° 16' W.
75TH MER. TIME
DECLINATION. AUGUST 21 1910
DEC. SCALE.
WEST
Noon 13 14 15 16 17 18 19 20 21 22 23 MID. 1 2 3 4 5 6 7 8 9 10 11
INCREASE
HORIZONTAL FORCE AUG: 21 1910
H.F. SCALE

Earthquake Records by Milne's Seismograph

TORONTO

R. F. Stupart, Director.

P.T. = Preliminary Tremors. L.W. = Large Waves. Time is Greenwich Civil Mean Time, 0 or 24 h = midnight.

No.	Date 1910	P.T Comm		L.W. Comm.		Max.		End.		Max. Amp.	Durat.		Remarks
		h	m	h	m	h	m	h	m	mm.	h	m	
937	Aug. 5	1	43·8	1	47·5	1	53·1	2	54·4	4·0	1	10·6	Tapered off gradually after Max.
				1	51·3								
938	" 11	16	41·4	16	45·3	16	46·0	17	33·3	4·5	0	51·9	Medium
939	" 21	5	57·2			6	10·2	7	18·7	0·5	1	21·5	Extended
940	Sept. 1	1	50·4					2	23·4	0·3	0	33·0	
941	" 1	15	25·0					15	44·5	0·05	0	19·5	
942	" 6	20	23·5					21	11·0	0·2	0	47·5	Marked thickenings
943	" 7	7	43·2					7	57·6	0·05	0	14·4	
944	" 7	8	15·8					9	20·2	0·10	1	4·4	Extended thickenings
945	" 7	10	57·7			11	5·0	11	35·5	0·8	0	37·8	Grad' swelling after L.W
946	" 8	23	43·8					24	6·5	0·05	0	22·7	May not be seismic
947	" 9	P_1 1	24·5	1	44·9	2	4·0	3	40·5	4·5	2	16·0	Medium and extended.
		P_2 1	31·8										
		P_3	41·1										
948	" 9	14	36·0					14	39·0	0·05	0	3·0	
949	" 24	3	44·7			3	55·8	4	10·5	1·0	0	25·8	Small and well defined
950	" 24	4	13·0			4	22·0	4	34·0	0·35	0	20·0	A fresh little disturb.
951	" 24	18	59·7					19	17·0	0·3	0	17·3	seismic
952	" 26	1	47·0					1	50·0?	0·05	0	53·0?	Doubtful as to being

Period 14·9 seconds. 1 mm. = 0″·64

VICTORIA, B. C.

E. B. Reed, Superintendent.

No.	Date 1909	P.T. Comm.		L.W. Comm.		Max.		End		Max. Amp.	Durat.		Remarks
		h	m	h	m	h	m	h	m	mm.	h	m	
971	Aug. 5	1	33·0	1	34·6	1	37·2	2	46·5	8·9	1	13·5	beginning Max. shortly after
972	" 6	7	29·1					7	39·2	0·1	0	10·1	Brief thickenings
973	" 11	16	41·4?			17	4·8	17	28·3	0·35	0	46·9?	
			48·4										
974	" 21	5	48·7	5	59·0	6	5·2	6	53·3	0·9	1	4·6	
975	Sept. 1	1	38·5					2	7·0	0·05	0	28·5	
976	" 1	15	14·5					15	17·0	0·05	0	2·5	
977	" 6	21	1·2					21	12·2	0·05	0	11·0	
978	" 7	7	24·4					8	25·2	0·2	1	0·8	
979	" 7	10	40·2			10	53·2	11	25·2	0·3	0	45·0	
980	" 9	P_1 1	19·5	1	25·3	1	27·0	3	13·3	1·1	1	54·0	Small, well defined.
		P_{11} 1	22·1										
981	" 10	12	49·4					12	54·5	0·1	0	5·1	
982	" 18	2	2·7					2	7·2	0·05	0	4·5	
983	" 24	3	39·8	3	54·0	3	56·8	4	11·8	1·6	0	32·0	Small but well marked
984	" 24	4	14·3					4	46·8	0·3	0	21·1	Another small dis.

Period 15 seconds. 1 mm. = 0″·76.

J. V.

BOOK REVIEWS

Les Théories Modernes du Soléil. PAR J. BOSLER.

In this new volume of the Encyclopédie Scientifique is given a statement of the principal positive results of solar investigation with a discussion of the different theories touching the more important outstanding questions. The names of M. Mascart, editor of the part of the Encyclopédie dealing with astronomy and astrophysics, and M. Bosler are a guarantee of the merits of the work, and the orderliness of treatment and lucidity of expression are what is to be expected in a French scientific treatise. After a statement of the generally known theories of Herschel, Kirchhoff, Zöllner, Secchi, Faye, Oppolzer, the author passes to the somewhat more recent speculations of Brester and to the optical theories of Schmidt and Julius. The chapter on the temperature of the sun and the sustenance of heat radiation is of extreme interest, and the concluding chapters on the thermal and dynamical solar equilibrium and on the electro-magnetic field of the sun are very stimulating and suggestive. The references to recent literature will enable the student to examine more fully into theories which on account of limited space could only be sketched. δ

The Principles and Methods of Geometrical Optics, especially as applied to the theory of optical instruments. BY JAMES P. C. SOUTHALL. Pp. 626, New York: The Macmillan Co., 1910. Price $5.50 net.

The part which Britain has played in the development of the theory of geometrical optics as well as in the construction of optical instruments has been of great and fundamental importance, but latterly this great branch of science, pure and applied, has passed largely into German hands. The optical engineers and artisans of the firm of Zeiss in Jena have in an extraordinary way advanced optical science, and the products of this firm are famous all over the world. The mechanical skill exhibited has, of course, contributed to this result, but the real cause of it is

directly traceable to the investigations of Abbe, Czapski and their fellows, who built upon the foundations laid by Gauss, Petzval, Seidel and others.

In Britain there have always been excellent works on optics, but usually they have been of a very academic nature, and of little assistance to the instrument maker. Taylor's *A System of Applied Optics* (1906) is a valuable exception. It was written by the inventor of the well-known "Cooke" photographic lenses, and in it the formulæ relating to systems of lenses are illustrated by reference to actual lenses constructed. There has, however, been a great lack of works treating the entire subject in a modern and practical manner.

Mr. Southall, who is professor of physics in the Alabama Polytechnic Institute, deserves high praise and strong encouragement for his attempt to supply the want. He has some hope by his effort (to quote from the preface) "of rekindling among the English-speaking nations interest in a study not only abundantly worthy for its own sake and undeservedly neglected, but still capable, under good cultivation, of yielding results of far-reaching importance in nearly every field of scientific research."

In the new treatment of geometrical optics the notions of the wave-theory are never lost sight of, and in the first chapter there is an account of the fundamental principles, written in a very clear and interesting manner. The thirteen chapters following, deal with reflection and refraction at plane and spherical surfaces, refraction through prisms and thin lenses, the theory of optical imagery, refraction through an optical system, spherical aberrations, color-phenomena, the aperture and the field of view, and the brightness of optical images. The whole is treated according to modern views, with the result that the subject, instead of being merely mathematical discipline becomes a useful branch of physics with valuable applications.

The diagrams are carefully drawn and really illustrate what is intended. The analytical expressions, even when somewhat long and cumbersome are presented in a form as simple and easily understandable as possible. Another valuable feature is the continual reference to original memoirs given.

It is to be hoped that the work will go far to realise the author's high aim. C. A. C.

ASTRONOMICAL NOTES

THE NEW ASTRONOMER ROYAL.—His Majesty the King has been pleased to approve of the appointment of Mr. Frank Watson Dyson, F.R.S., Regius Professor of Astronomy in the University of Edinburgh, and Astronomer Royal for Scotland, to the position of Astronomer Royal in succession to Sir William Christie, K.C.B., F.R.S., who retires on the 1st of this month (October 1).

Mr. Dyson was born on January 8, 1868. He was educated at Bradford Grammar School and afterwards at Trinity College, Cambridge, taking his degree as Second Wrangler in the Tripos of 1889. He was Sheepshanks Exhibitioner, Isaac Newton Student, Smith's Prizeman, and held a Fellowship at Trinity College. In March 1894 he succeeded Prof. Turner as Chief Assistant at Greenwich, and held that post until his appointment to Edinburgh at the end of 1905. Mr. Dyson was Secretary of the Royal Astronomical Society from 1898 to 1905, and was elected a Fellow of the Royal Society in 1901.—*Observatory*, No. 427.

THE ASTRONOMER ROYAL WHO RETIRES.—Sir W. H. M. Christie joined the staff at Greenwich in 1870 as Chief Assistant to Sir George Airy, whom he succeeded as Astronomer Royal in August 1881. The lengths of tenure of previous holders of the office have been: Flamsteed 44 years, Halley 22, Bradley 20½, Bliss 2, Maskelyne 46, Pond 25, Airy 46, so that Sir William Christie has been Astronomer Royal for a period of almost exactly average length—about 29 years. One result of his directorate at Greenwich is visible in the fine building in which the greater part of the work of the Observatory is now done, and the enlargement of the staff which this implies. The extension and improvement of the equipment is shown outwardly by the two large domes and the three smaller ones which have been added to the Observatory in the last quarter of a century. Sir William Christie is now 65 years of age, and he leaves his high office with the sincere wishes of his staff that he may add many to these in his well-earned retirement.—*Observatory*, No. 427.

NOTES AND QUERIES

Communications are Invited, Especially from Amateurs. The Editor will try to Secure Answers to Queries.

Notes of Travel

The traveller who crosses the continent in the middle of the summer must wonder where all the others come from. Train after train, every day in the week, carries onward its full complement of passengers ; and one must be an early bird to secure the more convenient "lower" in the sleeping car, leaving the airier and probably more healthful "upper" to the envious latecomer. The palace steamship which carried the writer over the upper lakes was also overcrowded, many passengers occupying beds improvised in the saloon. It is surely a matter for congratulation that so many are able to enjoy the pleasures of travel. As the horizon expands, the mind is enlarged, and the real greatness of one's country becomes evident.

One cannot stay many hours in a western town without being affected by the prevailing spirit of buoyancy. The inhabitants of each place are sure that it has a great future, and they proceed to lay out their streets and erect their public buildings on a comprehensive and splendid scale. Regina, which was visited on July 26, is an excellent example. An automobile tour with Sheriff Cook at the wheel and Police Magistrate Traut in the rear seat pointing out the many features of interest, (in such company you may rest assured we kept well within the speed limit), exhibited the importance of this "Queen City" as a commercial, political and educational centre. In the evening the writer was greatly surprised, as well as pleased, to see so many

come out in the middle of summer to listen to a lecture on popular astronomy. This was given in the assembly room of the Collegiate Institute building, a fine new edifice equipped with all the conveniences and facilities which modern education can suggest.

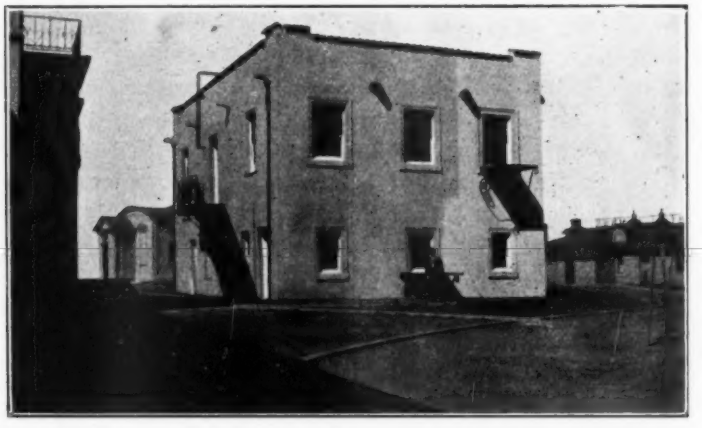
The meeting was held under the auspices of the Saskatchewan Astronomical Society. To those present the writer outlined the growth of the Royal Astronomical Society of Canada, and explained what steps were necessary for the local society to become a Centre of the national one. These steps have since been taken, and we now have a thriving and ambitious representative in the middle west. The chairman of the meeting was Mr. Wm. Trant, who, I was interested to learn, was a charter member of the Leeds Astronomical Society of England.

At Edmonton inquiries were still being made regarding Halley's Comet, which had been a disappointment to many. The wanderer 1910*a*, which appeared towards the end of January, had been seen to advantage, and some were even inclined to believe that Halley had passed them by without giving them an opportunity to see him at all. I explained that many in England were disappointed also and for the same reason. At the time when the comet was near the earth the twilight in those higher latitudes was so long that the visitor, being comparatively faint, could not be recognised in the bright sky.

The passage through the Rocky Mountains did not fail to give the impression of majesty and strength, but at length the Coast was reached. In Vancouver and Victoria are many pleasing and interesting features, and in Seattle and Portland one sees two picturesque and ambitious commercial centres. Observers in Oregon spoke more favorably of Halley's Comet, as it was seen very satisfactorily in these lower latitudes. San Francisco has risen again from the flames, the business portion being, perhaps, more magnificent than before, The encyclopædic conduc-

tor of the observation car informed us that $270,000,000 had been expended in rebuilding; but a few minutes on a street car will show ruins not yet cleared away.

The Lick Observatory, on Mount Hamilton, is reached from San Jose, which is fifty miles south of San Francisco. Until the present summer the trip to the summit was by stage leaving at 7.30 a.m. and arriving at the Observatory at about 1 p.m. The mountain road, which is twenty-five miles in length, is a beautiful one; but by the time stops had been made two or three times



THE NEW PHOTOGRAPHIC BUILDING OF THE LICK OBSERVATORY

to change horses and a somewhat longer delay had been made at Hotel Santa Ysabel (*alias* Smith Creek) the traveller was decidedly weary. But now all this is changed. At 8.45 a.m. we take our seats in a well-upholstered 30 H.-P. automobile and start forward; we exchange mail-bags and deliver letters at various post-boxes (for this is a rural mail route); we stop twenty minutes at the Ysabel; and after all reach the summit before noon! The return, of course, is made in even less time.

The Observatory appeared much the same as during the

writer's extended stay there in 1907. Perhaps the brick walls looked a little "smarter" in a recent coat of paint. In the rear of the main building is a new photographic house, built of re-inforced concrete and about as nearly fire-proof as it could be made. It is 52 feet long by 31 feet wide and two stories high. In it are stored the Observatory's invaluable series of photographic negatives; and in addition there are three dark rooms, an enlarging room 50 feet long and two rooms for the measurement of photographs.

But there have been several changes in the staff. Professor Perrine is now director and Dr. Albrecht chief astronomer at the Argentine National Observatory. Professor Tucker has leave of absence and with his former assistant on the Mountain, Mr. Sanford, is at San Luis in Argentina, in charge of the southern observatory of the Carnegie Institution. A catalogue of precision of the stars of the southern hemisphere is being prepared by Professor Tucker and his staff.

Director Campbell is still busy on his great spectroscopic programme, though he has recently published some valuable results deduced from his observations (see page 353). Professor Aitken has almost completed his search for new double stars in that part of the sky north of declination -22°. When it is done he hopes to continue the search over the remaining portion of the celestial sphere by working at some observatory in the southern hemisphere. A very generous offer has been made to him to use the large equatorial at Johannisburg, but no definite arrangements have yet been made. In the course of his work Professor Curtis obtained a very interesting collection of photographs of Halley's Comet and he has made some interesting measurements of them. Professor Wright is also engaged in spectroscopic work. His recent observations of the spectra of Comet 1910*a* and of Halley's Comet were interesting and important. The writer was pleased to meet Prof. H. C. Wilson, the editor of *Popular Astronomy*, who is spending a year's leave of absence from Carleton College, in work at the Observatory. One of the younger members of the staff is Mr. Reynold

Young, who graduated at the University of Toronto in 1908, winning the Society's gold medal; and the secretary of the Observatory is Miss R. Standen, formerly of Toronto.

The trip southward from San Jose along the Coast is very pleasing, many novel features appearing every few minutes, and in Los Angeles one sees a city which has had a remarkable growth. The citizens are very proud of their city, and do not shrink from great projects. Being rather short of a good supply of water, they have undertaken to bring it from mountain lakes and streams through a cement aqueduct 300 miles long at a cost of over $20,000,000. Los Angeles is only eleven miles from Pasadena, the roadway connecting the two cities passes through immense orange orchards and beside magnificent hotels built to accommodate the great army of winter visitors. The palms, acacias and the other beautiful semi-tropical vegetation make the northerner think that he is in the land of the picture-books, not in the real everyday world. Of the visit to Mount Wilson an account appears elsewhere.

More About Mars

Mr. W. F. Denning, the well-known Bristol observer and a long-time fellow of our Society, discusses the canals of Mars in *Knowledge* for September. He thinks the last few oppositions of Mars have furnished important evidence regarding the surface markings. According to him the double canals are an optical illusion, and he would rule out the net-work of narrow lines drawn by Lowell, Brenner and others, as incorrectly representing the condition of the planet. That there are dusky canals or channel-shaped markings on the planet must be admitted, but they do not exist in the same character or abundance as some modern observers have affirmed.

Mr. Denning thinks that Antoniadi's observations disprove the existence of the systems of hard geometrically-patterned lines, with which some have almost covered the planet. The

minor details or canals appeared irregular knotted and disconnected markings, presenting a perfectly natural appearance, suggesting that they are due to natural causes, not to artificial constructions.

In *Bulletin* 49 of the Lowell Observatory Professor F. W. Very gives the results of further measurements on the spectra of Mars and the moon. The conclusion, as before, is that the water-vapor band "*a*" in Mars is two and one-half times and band *B* one and one-half times as dense as in the lunar spectrum.

The Royal Observatory

The retirement of Sir William Christie from the position of Astronomer Royal, held by him since 1882, is made the occasion for a review, in *Knowledge* for October, of the improvements introduced by him at Greenwich. The Observatory has been almost remodelled. Telescopes have been multiplied and their sizes greatly increased. Adequate attention is also given to the astrophysical side. The new Astronomer Royal, is F.W. Dyson, recently Astronomer Royal for Scotland, though formerly of the Greenwich staff. Mr. Dyson was a delegate to the Solar Union at Mt. Wilson this summer.

C. A. C.

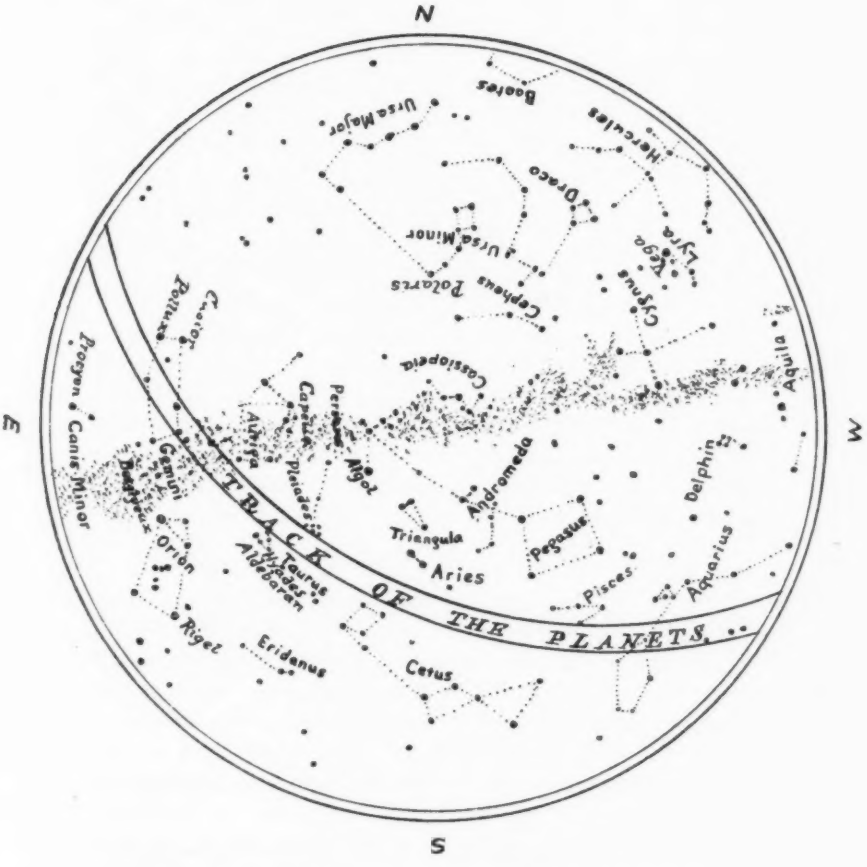
PREDICTIONS FOR NOVEMBER AND DECEMBER

Constellations on the Meridian in November

Cassiopeia, one of the two bright circumpolar constellations, is named from a queen of Grecian mythology ; also sometimes known by the name of *The Lady in her Chair*. During November it is on the meridian, directly above the pole and opposite the Dipper, about nine o'clock. The constellation is very easily recognised by five bright stars arranged in a zigzag figure like a wide inverted W, which in certain positions is said to resemble the outline of a chair. Lying, as it does, in the galaxy, it contains many fine telescopic fields.

Andromeda is directly to the south of Cassiopeia, and passes the meridian slightly south of the zenith. Its brightest star, Alpherat, passes meridian at the same time as the most westerly of the five bright stars in Cassiopeia. β, once known by the name, (now entirely out of use), of Mirach Mizar, passes the meridian an hour after Alpherat and about 7° nearer to the zenith. One of the most interesting features of this constellation is the Great Nebula, the only one visible to the unaided eye, which may be located by prolonging the line joining β and μ to its own length beyond μ.

Pegasus, the winged horse of Grecian mythology, lies immediately to the south-west of Andromeda ; three bright stars in it form with Alpherat, in Andromeda, a large and conspicuous figure known as the Square of Pegasus, each side of the square being about 14° in length. The boundaries of the constellation extend a considerable distance to the west and south-west, taking



THE CONSTELLATIONS ON DECEMBER 1, AT 9 P.M.

(Drawn after a map in Ball's *Popular Guide to the Heavens*.—London: Philip.)

in the bright star ϵ, which lies west and a little south of the star in the right hand lower corner of the square.

Pisces, (The Fishes), is to the southeast and east of Pegasus and south of Andromeda. It is the twelfth sign and the first constellation of the Zodiac ; although containing quite a large number of stars, none of them are brighter than the fourth magnitude, and it is a quite inconspicuous constellation. It is occupied by the sun from March 15 to April 16.

Cetus, (The Whale), is a fairly large constellation lying to the southeast of Pisces. It contains two stars, α and β, of the second magnitude, and eight of the third. β may be identified by prolonging the eastern side of the Square of Pegasus about two and a half times its own length to the south ; α lies about 40° towards the northeast. About one-third of the way from α to β, in a direct line between them, lies Mira (The Wonderful), a variable star, having a period of about eleven months ; at its maximum brilliancy this star is somewhat brighter than the second magnitude, though it does not attain this degree of brightness in every period ; its minimum is about the ninth magnitude ; the last maximum occurred about the end of September last.

Constellations on the Meridian in December

Aries, (The Ram), the first sign and second constellation of the Zodiac, lies immediately to the north-east of Pisces. Its brightest star α, otherwise known as Hamal, is of the second magnitude ; it is situated directly east from the centre of the Square of Pegasus, at a distance of about double the diameter of the latter ; near it to the south-west, is β, of the third magnitude ; the constellation contains no other stars brighter than the fifth magnitude.

Triangulum, (The Triangle), is a small constellation marked by a right-angled triangle of three stars of the third magnitude. The centre of the triangle lies about ten degrees directly north of Hamal.

Perseus, named after a hero of Grecian mythology, lies to the east of Andromeda and north-east of Aries. Its brightest

star, α, is known by the name of Mirfak ; it is of the second magnitude, and crosses the meridian slightly north of the zenith at nine o'clock (local time) on December 26. About ten degrees a little west of south from it is Algol (The Demon), the best known variable star in the heavens. Ordinarily of the second magnitude, but once in every period of two days and nearly twenty-one hours it is partially eclipsed by a companion which revolves around it ; the eclipse occupies eight or ten hours, during about half an hour of which it is only of the fourth magnitude. It is easily located by noting that it is a little less than half way from the Pleiades to Cassiopeia. Another interesting feature of this constellation is the double cluster, lying about half way between Mirfak and Cassiopeia, which is referred to in Predictions for November.

Mercury

Mercury will be in aphelion on November 21, and in conjunction with the moon on December 2. The planet is south of the ecliptic, but will cross to the north on December 30. On December 24 it will be visible about an hour after the sun in the western sky.

Venus

Venus will be close to the sun during November. On the 25th instant, it will be in superior conjunction with the sun. On December 1 and 31 Venus will be in conjunction with the moon but too close to the sun to be readily seen.

Mars

November 29 Mars will be in conjunction with the moon just before the rising sun in the eastern sky. During December the planet will be advanced a couple of hours before the sun.

Jupiter

Jupiter is also advancing gradually ahead of the sun and will be morning star during December and will be in conjunction with the moon on Christmas Day.

Saturn

Saturn rises now at sunset and will continue to rise earlier each night, being in good position for observation. A patch resembling a polar cap has been recently noticed on this planet.

Uranus

Uranus moves slowly through Sagittarius during November and December, crossing the meridian about 25° above the southern horizon.

Neptune

Neptune during November and December is moving slowly through Gemini, in December it will cross the meridian about midnight.

Double Stars for Small Telescopes

[illegible] *iopeiæ*, R. A. 0h 43m; Dec. 57° 17′ N. Magnitudes 4, 7·6. Large star orange; small one purple. About half-way between α and γ, a little off the line. This is a binary star and, being within the reach of small telescopes, it has been measured many times. Distance apart in 1832, 9″·7; in 1860, 7″·2; in 1887, 5″·0; in 1899, 5″·2. Computations of the period range from 167 to 500 years. The period given by Doberck, 222 years must be considered only roughly approximate.

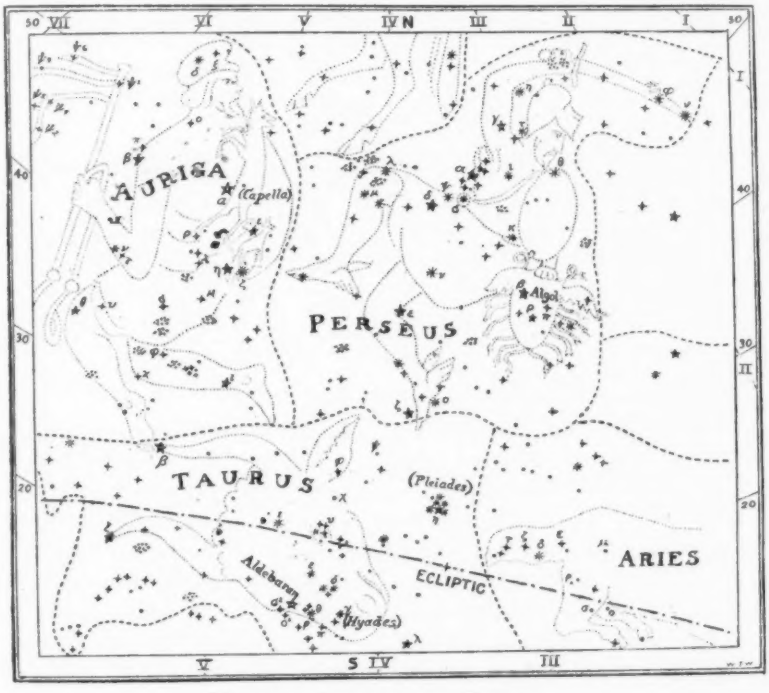
α *Cassiopeiæ*. R. A. 0h 35m; Dec. 56° 0′ N. Magnitudes 2, 9; distance 63″·2. Colors, yellow and bluish. A very wide double star, but the companion is faint in small telescopes.

γ *Andromeda*. R. A. 1h 58m; Dec. 41° 51′ N. Magnitudes 3, 5; distance 10″·3. Colors, gold and blue. One of the most beautiful pairs in the heavens, but not a binary. First noticed by C. Mayer in 1788. The small star is itself double, and has been found to be a binary. The distance is 0″·46 and so is beyond a small telescope.

π *Andromeda*. R. A. 0h 32m; Dec. 33° 11′ N. Situated 2° north and a little west of δ. Magnitudes 4, 8; distance 36″. Yellowish and blue. This is a spectroscopic binary.

κ *Pegasi*. R. A. $21^h\ 40^m$; Dec. 25° 11′ N. Magnitudes 4, 11. The large star is itself a binary with a period of about 11 years, discovered in 1880 by Barnard with an 18½ inch telescope.

α *Piscium*. R. A. $1^h\ 57^m$; Dec. 2° 17′ N. Magnitudes 3, 4; distance 2″·6; white and blue. Probably a binary system,



TAURUS, AURIGA AND PERSEUS

but the period is long and the motion slow. Distance in 1831, 3″·64; in 1872, 3″·14; in 1887, 2″·96; in 1901, 2″·61.

γ *Ceti*. R. A. $2^h\ 38^m$; Dec. 2° 48′ N. Magnitudes 3, 7; distance 3″; yellowish and ash. The components have a common proper motion, and, therefore, probably form a physical system.

γ *Arietis*. R. A. $1^h\ 48^m$; Dec. 18° 49′ N. Magnitudes 4·2, 4·4; distance 8″·6; very white. Discovered by Hooke in following the comet of 1664; the second double star seen by any observer. "I took notice that it consisted of two small stars very near together; a like instance to which I have not else met with in the heaven." Good object for small telescopes.—Webb.

ι *Trianguli*. R. A. $2^h\ 7^m$; Dec. 29° 50′ N. Magnitudes 5, 6·5; distance 4″; yellow and blue.

ϵ *Persei*. R. A. $3^h\ 51^m$; Dec. 39° 43′ N. Magnitudes 3, 8; distance 8″·8; green and bluish-white.

η *Persei*. R. A. $2^h\ 43^m$; Dec. 55° 29′ N. Magnitudes 4, 8·5; distance 28″; orange and blue.

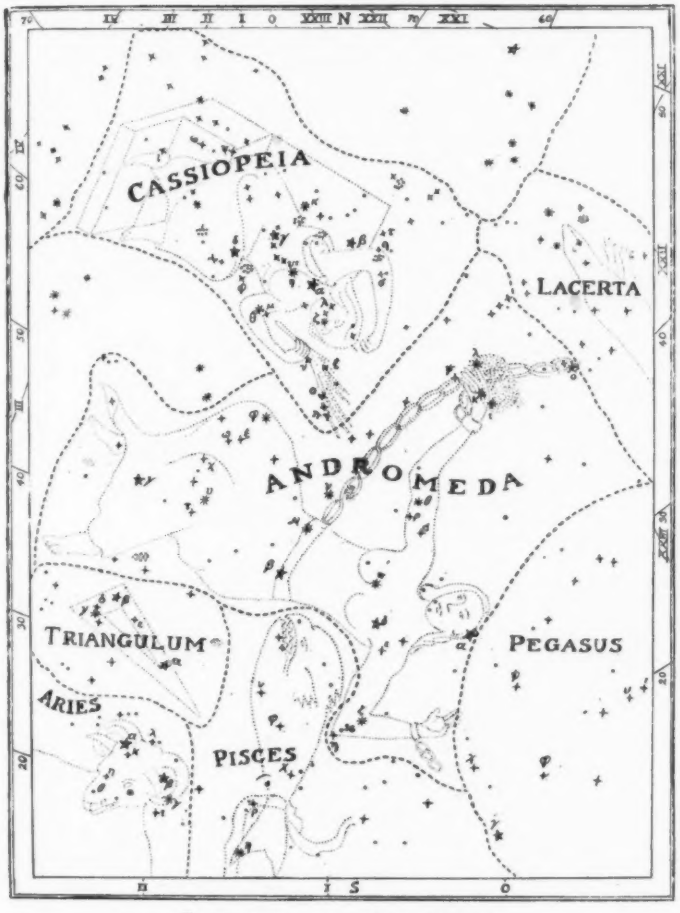
ζ *Persei*. R. A. $3^h\ 47^m{\cdot}8$; Dec. 31° 35′ N. Magnitudes 2·7, 9·3; distance 12″·5. Greenish-white and ash-colored. Three other distant companions.

Nebulæ and Star Clusters

Great Nebula in Andromeda. R. A. $0^h\ 38^m$; Dec. 40° 46′ N. (*Messier* 31). With a clear sky and no moon this nebula can be detected with the naked eye, and seen clearly with an opera glass. It is referred to as a familiar object by the Persian astronomer Sufi, in the tenth century. A photograph by Roberts in 1888 clearly showed that the nebula is a flat spiral seen obliquely, and later photographs have confirmed this view. In the spectroscope the nebula gives a continuous spectrum, indicating that the nebula is not a gaseous mass but rather a highly condensed star cluster. In August 1885 a new star of 6·5 magnitude was discovered near the centre of the nebula, but by the summer of 1886 it had disappeared entirely.

Messier 32. This is a small but bright nebula seen in the same field with the Great Nebula when a low power is used. In reality it is a cluster, but a very powerful instrument is required to distinguish the separate stars.

Cluster in Pegasus, Messier 15. R. A. $21^h\ 24^m$; Dec. 11°



CASSIOPEIA AND ANDROMEDA

38′. Recognised as a nebula by Maraldi in 1745 but resolved into a globular cluster by Herschel.

Clusters in Perseus (*H.* VI. 33, 34). R. A. $2^h\ 14^m$; Dec. 56° 40′ N. Half-way between γ Persei and δ Cassiopeia. These two clusters are often called *the sword-hand of Perseus*, and are

AT GREENWICH MEAN NOON

Date 1910	Day of Year	The Sun's Right Ascension	The Sun's Declination	Equation of Time Add to Mean Time	Sidereal Time
		h m s	° ′ ″	m s	h m s
Tues. 1	305	14 23 16·44	S. 14 14 43·5	16 18·08	14 39 34·53
Fri. 4	308	14 35 4·10	15 11 50·6	16 20·09	14 51 24·19
Mon. 7	311	14 46 59·05	16 6 42·3	16 14·80	15 3 13·86
Thur. 10	314	14 59 1·39	16 59 8·0	16 2·13	15 15 3·53
Sun. 13	317	15 11 11·20	17 48 56·3	15 42·01	15 26 53·20
Wed. 16	320	15 23 28·50	18 35 56·9	15 14·37	15 38 42·87
Sat. 19	323	15 35 53·35	19 20 0·0	14 39·19	15 50 32·54
Tues. 22	326	15 48 25·72	20 0 55·5	13 56·49	16 2 22·21
Fri. 25	329	16 1 5·43	20 38 34·3	13 6·46	16 14 11·81
Mon. 28	332	16 13 52·15	21 12 46·5	12 9·40	16 26 1·55

75th Meridian Time, Hours numbering from Midnight

Planetary Phenomena

			Minima of Algol	Configuration of Jupiter's Satellites. 5h 3m
			h m	
● Tues.	1	20h 56m·1 New Moon; 5h 2m ☌ ☿☾, ☿ 0° 33′ S.; 6h 45m ☌ ♂☿☾, ♂ 0° 28′ S.; ☉ part eclipse invis. in Can.		
Wed.	2		16 36	
Thur.	3	13h·2 ☾ in Apogee, 4h ☌ ♂☿, ♂ 0° 10′ S.		
Fri.	4	9h ☌ ♂♃, ♂ 0° 33′ S.		
Sat.	5		13 25	
Sun.	6			
Mon.	7	23h 6m ☌ ♅☾, ♅ 4° 14′ N.		
Tues.	8		10 14	
Wed.	9			
☽ Thur.	10	0h 29m·4 First Quarter.		
Fri.	11	16h ☿ in ♍.	7 3	
Sat.	12	9h ☌ ☿ ☉ Superior.		
Sun.	13			
Mon.	14		3 52	
Tues.	15	9h 1m ☌ ♄☾, ♄ 1° 13′ S.		
○ Wed.	16	19h 25m Full Moon; ☾ in Perigee 21h·8; ☾ total eclipse vis. in Canada.		
Thur.	17		0 41	1○234
Fri.	18			2○134
Sat.	19		22 30	1○34●
Sun.	20	14h 42m ☌ ♆☾, ♆ 5° 22′ S.		3○124
Mon.	21	22h ☿ in Aphelion.		312○4
Tues.	22		18 19	32○14
☾ Wed.	23	13h 13m·4 Last Quarter.		1○342
Thur.	24			4○123
Fri.	25		15 8	42○3●
Sat.	26	8h ☌ ♀ ☉ Superior.		41○3●
Sun.	27			43○12
Mon.	28	16h 9m ☌ ♃☾, ♃ 0° 23′ S.	11 57	4312○
Tues.	29	17h 21m ☌ ♂☾, ♂ 0° 0′.		432○1
Wed.	30	14h ☾ in Apogee.		41○2●

Key to Symbols.—☌ Conjunction; ☍ Opposition; □ Quadrature; ☊ Ascending Node; ☋ Descending Node; ☉ Sun; ☿ Mercury; ♀ Venus; ⊕ Earth; ♂ Mars; ♃ Jupiter; ♄ Saturn; ♅ Uranus; ♆ Neptune.

At Greenwich Mean Noon

Date 1910	Day of Year	The Sun's Right Ascension	The Sun's Declination	Equation of Time Add to / Sub't from Mean Time	Sidereal Time
		h m s	° ′ ″	m s	h m s
Thur. 1	335	16 26 45·40	S. 21 43 23·0	11 5·83	16 37 51·23
Sun. 4	338	16 39 44·56	22 10 15·1	9 56·35	16 49 40·91
Wed. 7	341	16 52 48·94	22 33 15·1	8 41·64	17 1 30·58
Sat. 10	344	17 5 57·79	22 52 16·5	7 22·47	17 13 20·26
Tues. 13	347	17 19 10·30	23 7 14·1	5 59·63	17 25 9·03
Fri. 16	350	17 32 25·70	23 18 3·5	4 33·91	17 36 59·61
Mon. 19	353	17 45 43·27	23 24 42·2	3 6·01	17 48 49·28
Thur. 22	356	17 59 2·25	23 27 7·7	1 36 71	18 0 38·96
Sun. 25	359	18 12 21·75	23 25 19·1	0 6·89	18 12 28·64
Wed. 28	362	18 25 40 81	23 19 16·3	1 22·50	18 24 18·31
Sat. 31	365	18 38 58·48	23 9 0·5	2 50·49	18 36 7·99

75th Meridian Time, Hours numbering from Midnight

Planetary Phenomena	Minima of Algol	Configuration of Jupiter's Satellites at 5h.
	h m	
Thur. 1 16h 10m·7 New Moon; 19h 47m ☌ ☿ ☾, ☿ 2° 2′ N.	9 46	4○123
Fri. 2 17h 5m ☌ ☿ ☾, ☿ 0° 49′ N.		21○43
Sat. 3		2142○34
Sun. 4 4h ☿ in ☍.	6 35	3○124
Mon. 5 7h 7m ☌ ♃ ☾, ♃ 4° 15′ N.		2131○4
Tues. 6		32○14
Wed. 7	3 24	13○24
Thur. 8		○1234
First Quarter. 9 14h 5m·4 First Quarter.		21○43
Sat. 10	0 13	2○143
Sun. 11		43○2●
Mon. 12 7h ☿ Greatest Hel. Lat. S.; 16h 56m ☌ ♄ ☾, ♄ 1° 2′ S.	21 2	431○2
Tues. 13		432○1
Wed. 14		413○2
Thur. 15 10h·7 ☾ in Perigee.	18 51	4○132
Full Moon. 16 6h 5m·1 Full Moon.		421○3
Sat. 17		42○13
Sun. 18 0h 25m ☌ ♆ ☾, ♆ 5° 16′ S.	15 40	4○32●
Mon. 19		31○42
Tues. 20		32○14
Wed. 21	12 29	31○4●
Thur. 22 17h ☉ enters ♑ (Capricornus). Winter commences.		○3124
Last Quarter. 23 5h 36m 6 Last Quarter.		12○34
Sat. 24 13h ☿ Greatest Elong. E. 19° 54′.	9 18	2○134
Sun. 25		1○324
Mon. 26 9h 20m ☌ 2 ☾, 2 0° 16′ N.; 18h ☌ ☿ ♃, ☿ 0° 36′ S.		213○24
Tues. 27 21h·3 ☾ in Apogee.	6 7	32○41
Wed. 28 17h 13m ☌ ♂ ☾, ♂ 1° 38′ N.		341○●
Thur. 29		4○312
Fri. 30	2 56	412○3
Sat. 31 11h 21m·2 New Moon; 7h ☿ in ♑; 20h ☿ Stationary.		42○13

For Jupiter's Satellites, the circle ○ represents the disc of the planet; 2 signifies that the satellite is on the disc; ● signifies that the satellite is behind the disc or in the shadow. Configurations are for an inverting telescope.

considered, perhaps, the most magnificent of such objects in the heavens.

Cluster in Perseus, Messier 34. R. A. $2^h\ 34^m$; Dec. 42° 11′. Just perceptible to the naked eye: grand low-power field. It contains a pretty double star of 8th magnitude, components 20″ apart.

Cluster in Perseus (*H.* VI. 25). R. A. $3^h\ 8^m$; Dec. 46° 53′ N. A beautiful cluster 8′ in diameter, rich in stars of magnitude 10 and fainter, discovered by Herschel on December 27, 1786. A low power shows a very faint large cloud of minute stars beautifully bordered by a bright foreshortened pentagon.

Cluster in Perseus, (*H.* VII. 61). R. A. $4^h\ 8^m$; Dec. 50° 59′ N. Bright cluster, rich in stars, nearly 15′ in diameter, with some fairly brilliant stars, apparently in curves. Good low-power object.

Planetary Nebula in Eridanus. R. A. $4^h\ 10^m$; Dec. 13° 0′ S. Bright and round, discovered by Herschel in 1785, who took it to be a star cluster, a view supported by the fact that its spectrum is not gaseous.

ECLIPSES AND TRANSITS OF THE SATELLITES OF JUPITER

E = eclipse, O = occultation, T = transit, S = shadow, D = disappearance, R = re-appearance, I = ingress, e = egress.

Eastern Standard Time; hours numbering from midnight.

NOVEMBER

d	h	m			d	h	m			d	h	m		
19	6	5	II.	OR	**26**	5	1	II.	ED	**30**	5	50	III.	ER

DECEMBER

d	h	m			d	h	m			d	h	m		
2	5	50	I.	ED	**12**	5	5	II.	SI	**25**	5	58	I.	ED
3	5	10	I.	Se		6	47	II.	TI	**26**	4	5	I.	TI
	5	53	I.	Te	**17**	6	43	I.	SI		5	17	I.	Se
5	5	7	II.	Se	**18**	4	5	I.	ED		6	18	I.	Te
	6	39	II.	Te		5	37	III.	TI	**27**	3	38	I.	OR
10	4	50	I.	SI	**19**	4	20	I.	Te	**28**	4	31	II.	ED
	5	39	I.	TI	**21**	6	27	II.	OR	**30**	4	18	II.	Te
11	5	12	I.	OR	**25**	5	49	III.	SI					